ICoSTechS 2016
International Conference on Science and Technology for Sustainability

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PROCEEDING

The 2nd International Conference on Science and Technology for Sustainability 2016

"Sustainability and e-Health"

30th November - 1st December, 2016
Pangeran Hotel, Pekanbaru
Riau, Indonesia

Supported by

PENERBIT & TOKO BUKU ZANAFA

CoSTechS 2016

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FOREWORD

We welcome you to the 2nd International Conference on Science and Technology for Sustainability (IcoSTechS) eld in Pekanbaru, Indonesia, 30th November - 1st December 2016. It is with deep satisfaction that I write this Foreword to the Proceedings of IcoSTechS.

ICoSTechS continues a tradition of bringing together researchers, academics and professionals from all over the world, experts in science and Technology.

The main objective of the conference is to provide the opportunities for collaboration and reflection that have the potential to greatly enhance the infrastructure and capacity for conducting and applying science and technology for sustainability. The IcoSTechS is expected to bridge the gap between academia, business, industries, and governments by creating awareness of current development in sustainable technologies.

Thank you for all authors and participants for your contributions. Your contributions helped to make the Conference as outstanding as it has been. The papers contributed the most recent scientific knowledge known in the field of Information Technology, Industrial Engineering, Electrical Engineering and Mathematics Sciences.

In addition, I would like to thank you for two keynote speaker **Prof. Yasutomi Kinosada** from School of Medicine, Gifu University, Japan, and by **Prof. Dr. Ing. Ir. Kalamullah Ramli, M.Eng,** Director General of Post and ICT Operations of the Ministry of Communication and Information Technology (2013 – 2016), Indonesia.

These Proceedings will furnish the scientists of the world with an excellent reference book. I trust also that this will be an impetus to stimulate further study and research in all these areas. We are pleased to present the proceedings of the conference as its published record.

Dr. Harris Simaremare, MT
Conference Chair

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REMARK

Assalamu'alaikum wr. wb.

Welcome to Pekanbaru,

It is my great pleasure and privilege to welcome all of you to 2nd International Conference on Science and Technology for Sustainability (IcoSTechS), which bring together key representatives from your expert research area. We are indeed pleased that so many eminent speakers in these field are present to lead the discussion.

It is our commitment to play roles together with international communities in education and research. In line with this commitment, we held the 2nd International Conference on Science and Technology for Sustainability (IcoSTechS) in Pekanbaru.

Please allow me to give my great appreciation to all of the committee members, International Honorary Board and all stockholders that helped to make this Conference as outstanding as it has been.

The last, please enjoy your time in Pekanbaru and see you in the next conference.

Wassalamu'alaikum wr. wb.

Dr. Hartono, M.Pd
Dean of faculty Science and Technology
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ICOSTECHS 2016 SCHEDULE

Wed, November 30th, 2016

CONFERENCE DAY

07.30 – 09.10 **Opening Ceremony**
Coffee Break

09.30 – 12.00 **Session I Presentation from Keynote Speaker**
Prof. Yasutomi Kinosada
Moderator : Wresni angraini, ST., MM

Prof. Dr. Ing. Ir. Kalamullah Ramli, M.Eng.
Moderator : M. Jasman, S.Kom, M.InfoSys

13.30 – 16.00 **Session II Parallel Presentation**
Moderator Room A : Idria maita, S.Kom., M.Sc
Moderator Room B : Saide, S.Kom, M.Kom, M.I.M
Coffee Break

21.00 – 21.15 **Closing Ceremony**

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PARALLEL SESSION SCHEDULE

Room A

NO	NAME	PAPER CODE	TIME
1	Rajesh Kumar	2	13.30 – 13.45
2	Fatihah Shafiqah	3	13.45 – 14.00
3	Eflita Yohana	19	14.00 – 14.15
4	M. Marizal	11	14.15 – 14.30
5	Muhammad Ihsan Zul	8	14.30 – 14.45
	Break		14.45 – 15.00
6	Fitri Aryani	23	15.00 – 15.15
7	Indra Wijaya	15	15.15 – 15.30
8	Yahya Badrussalam	13	15.30 – 15.45
9	Mustakim	22	15.45 – 16.00

Room B

NO	NAME	PAPER CODE	TIME
1	Enwelum I Mbadiwe	6	13.30 – 13.45
2	Laili Iwani	4	13.45 – 14.00
3	Liliana	10	14.00 – 14.15
4	Maxrizal	20	14.15 – 14.30
5	Keumala Anggraini	14	14.30 – 14.45
	Break		14.45 – 15.00
6	Riswan Efendi	7	15.00 – 15.15
7	lia anggraini	18	15.15 – 15.30
8	Rahmat Rizal Andhi	17	15.30 – 15.45
9	Riwinoto	5	15.45 – 16.00

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Influence of Rotor Pole Number on the Performance of Outer Rotor Permanent Magnet Flux Switching Machine for Downhole Application

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Locked Bag 101, Parit Raja, Johor, Malaysia.

Abstract—**In recent years, stator permanent magnet flux switching machine (PMFSM) has become more popular due to better cooling capability, higher efficiency, robust rotor and torque density but fewer were developed for downhole application because of high atmospheric temperature. Beside this, the modern researches are mainly focused on inner rotor type machines, with barely focused on the outer rotor. Therefore, this paper presents the influence of rotor pole number (N_r) on the performance of outer rotor permanent magnet flux switching machine. Under some design specifications and limitation, design methodology and preliminary outcomes of the suggested machine at various rotor pole number and 12 stator slots are examined. At the beginning, the arrangement of coils is inspected in order to validate the principle of operation and polarity of each armature coil phase. Then, the profile of flux linkage, back electromotive force (EMF), cogging torque, output torque, speed and power characteristics at assorted armature current density condition are analyzed based on 2D-FEA. Finally, the corresponding results show that the 12s-22p is a pertinent combination which initially provides highest output torque and power.**

Keywords— Downhole application; flux switching; outer rotor; permanent magnet; rotor pole;

I. Introduction

The current and forthcoming market for machines places high priority on torque density, operating efficiency, reliability, variable speed application and low cost. Permanent magnet (PM) machines are now competent to meet the market demands [1]. Compared with conventional induction machines, which are widely utilized in downhole applications, PM machine provides the qualities of high efficiency, better reliability and also additional advantages of higher torque density, superior power factor and synchronous operation but few were designed for downhole application due to high ambient temperature in deep wells and the low temperature stability of PM material over the time [2].

Recent development in magnet technologies allows operation at higher temperature without permanent magnetization loss. Now, it is high time for oil and gas sectors to replace prolific induction machine with PM machine [3].

The permanent magnet flux switching machine (PMFSM) has a brief history and is a relatively new kind of PM machines. The first PMFSM was reported as a single phase alternator in 1955 utilizing a low performance magnet shown in *Fig.1 (a)* [4], while a three phase machines was introduced in 1997 where ferrite was adopted to observe the flux focusing effect shown in *Fig.1 (b)* [5]. More recently, there has been revived research significance in PMFSM, probably due to numerous perceived benefits. Since active parts such as armature windings and permanent magnet placed on the stator, thus simple but effective machine cooling can easily be applied [6]. Furthermore, supplementary benefits such as robust rotor structure, high torque, high efficiency and better flux weakening capability are comprehensively examined and endorsed for various applications shown in *Fig. 2* [7-9]. However, research on PMFSM mainly associated with general electromagnetic investigation, design refinement and optimization of the inner rotor type [10-12], with barely any attention given to the outer rotor PMFSM.

This paper is related to the PMFSM with outer rotor configuration for downhole application. Different rotor pole numbers for the suggested machine with 12 stator slots have been analyzed in order to figure out the initial performance. The outcomes of rotor pole number on the electromagnetic performance such as flux linkage, cogging torque, induced voltages; average output torque and power are examined based on two dimensional finite element analyses (2D-FEA).

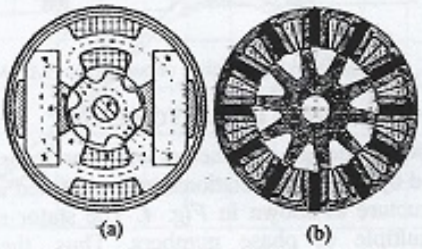

Fig. 1: (a) Single phase alternator (b) Three phase brushless machine

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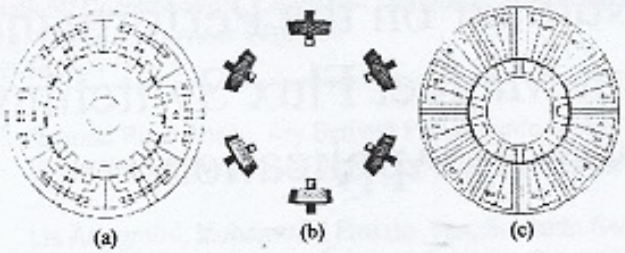

Fig. 2: (a) Direct drive (b) Aerospace (c) Downhole

II. Operating Principle

The elementary principle of operation for outer rotor PMFSM has been illustrated in [13]. Similarly, the same phenomenon is applied in the proposed design.

In *Fig. 3*, uppermost part is the laminated rotor similar to that of the switched reluctance machine (SRM). The lower of part of machine labeled as stator, consist of armature winding and PM. The PM is situated in between two stator teeth, and establishes a self-excited flux with a fixed direction within itself. In *Fig. 3 (a)* when rotor pole aligns with the one of the stator teeth over which a coil is wound, the PM generated flux is linked in the coil goes into the rotor pole. In *Fig. 3 (b)* when rotor moves ahead in order to align with the next stator teeth belongs to the same coil, the injected flux is drawn back to the stator tooth by the rotor pole, keeping the same value of flux-linkage while reversing the polarity, i.e. realizing the flux-switching concept. Consequently, as the rotor moves forward, the flux linkage in the coils will change periodically, inducing back EMF. Therefore, if current is properly fed into the coils, an electromagnetic torque will be developed, driving the rotor to move further.

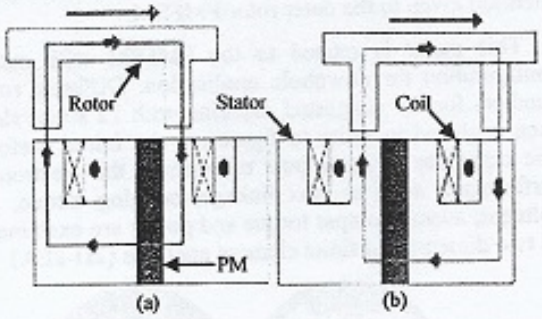

Fig. 3: Working principle of outer rotor PMFSM

III. Design Topology

The basic design parameters of outer rotor PMFSM are restricted by geometric relationship are defined in a magnified local structure as shown in *Fig. 4*. The stator slot should be even multiple of phase numbers. Thus, the relationship between stator slot number and N_s rotor pole number N_r is [14].

$$N_r = \frac{(12 \pm n) * N_s}{6} \qquad (1)$$

Where n is a positive integer which should not be a multiple of three. N_r is preferred to be even number so that zero resultant magnetic force can be achieved. In proposed design is selected N_r as 10, 14 and 22.

The basic design parameters such as PM width, tooth width β_s, rotor pole width β_r and stator arc width β_{slot} initially set as

$$\beta_{pm} = \beta_s = \beta_r = \frac{\beta_{slot}}{3} = \frac{\pi}{3} \qquad (2)$$

On the other hand, relationship between inner radius outer radius R_{si} and outer radius R_{so} originally

$$R_{so} = \frac{R_{si}}{2} \qquad (3)$$

Moreover, stator back length h_{ys} and rotor yoke are originally fixed as

$$h_{yr} = 1.5 * h_{ys} \qquad (4)$$

In order to achieve sufficient rotor saliency, the height h_{pr} is chosen as

$$h_{pr} = \frac{R_{so}}{8} \qquad (5)$$

Additionally, the winding area of armature and coil number of phase N_c can be determined as

$$A_{slot} = \frac{R_{so}^2 * Sin\left(\frac{\pi}{2 * N_s}\right)}{2 * Tan\left(\frac{\pi}{N_s}\right)} \qquad (6)$$

$$N_c = \frac{N_s}{m} \qquad (7)$$

Where, N_s is the stator slot number and m is number. Apart from this, number of turns N_a for area and peak injected current I_m in each coil can be as

$$N_a = \frac{2 * A_{slot} * \alpha}{\pi * d^2} \qquad (8)$$

$$I_m = \frac{A_{slot} * J_a * \alpha}{N_a} \qquad (9)$$

Where, α is filling factor, d is the diameter armature current density in rms.
Finally, rotor outer radius R_{ro} can be determined as

$$R_{ro} = \left(\frac{9}{8} + \frac{\pi}{2 * N_s}\right) * R_{so} + g \qquad (10)$$

Where, g is the air gap. The key geometric para calculated by using above mentioned equations are TABLE. I.

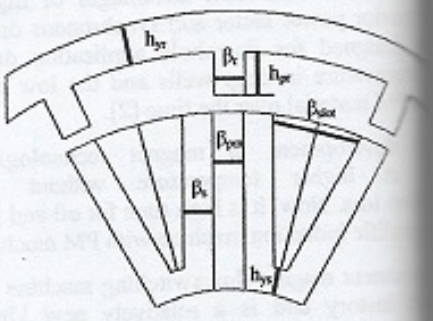

Fig. 4: Basic Design Parameters

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TABLE. I: DESIGN SPECIFICATION FOR OUTER ROTOR PMFSM

Parameters	Abbreviations	Values	Units
Stator Pole Number	N_s	12	
Rotor Pole Number	N_r	10,14,22	
Rotor Outer Radius	R_{ro}	50	mm
Rotor Inner Radius	R_{ri}	40.5	mm
Stator Outer Radius	R_{so}	40	mm
Stator Inner Radius	R_{si}	20	mm
Rotor Pole Height	h_{pr}	5	mm
Rotor Pole Width	β_r	3.49	mm
PM Width	β_{pm}	3.49	mm
Stator Tooth Width	β_s	3.49	mm
Rotor Yoke Length	h_{ry}	4.5	mm
Stator Back Length	h_{ys}	3	mm
Slot Area	A_{slot}	50.729	mm
Air Gap	g	0.5	mm
Stack Length	L	200	mm
PM Weight	W	1.26	Kg
Current Density	J_s	30	A/mm^2
Synchronous Speed	ω	1000	r/min
Number of Turns	N_s	33	
Split Ratio	λ	0.8	

From the above mentioned specifications, it is calculated that 80% area of the proposed designed is occupied by stator shown in *Fig. 5*, which is valid according to outer rotor PMFSM design principle.

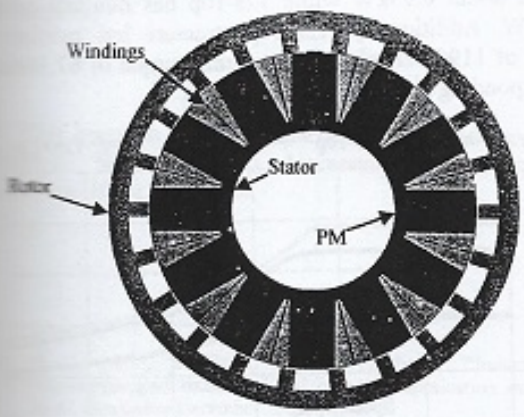

Fig. 5: Cross-sectional view of 12s-22p

IV. Performance Analysis Based On FEA

For conventional inner rotor PMFSM, the rotor pole number N_r is normally designed as close to the stator pole number N_s to enhance the machine performance [15]. However, the geometric configuration in outer rotor machine has been proved that larger N_r is more preferable for electrical vehicles [16]. Therefore, the fundamental objective of this work is to investigate the pertinent N_r that can provide maximum torque and power on the initial machine design for downhole application. Hence, in this study stator slot number N_s is set as 12, while rotor pole number Nr is chosen as 10, 14 and 22 respectively as shown in *Fig. 6(a,(b)and (c)*.

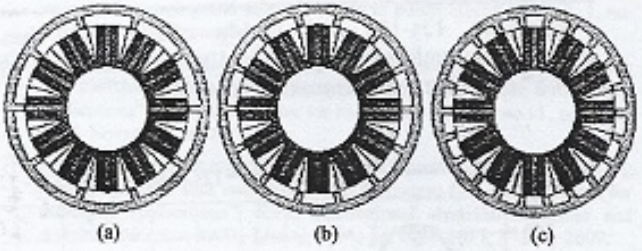

Fig. 6: Cross-sectional view of (a)12s-10p, (b)12s-14 (c)12-22p

A. Armature Coil Test Adjustement

Firstly, the operating principle for outer rotor PMFSM with different N_r combination is inevitably to be ratified in order to investigate the placement of armature coil phases. For each configuration, coil test arrangement is determined independently in all 12 armature coils. In order to carry out this test, armature coils supply is set at 0 A so the net flux is generated by PM only. The flux linkage developed by PM is observed on each armature coil windings keeping armature windings in counter clock wise direction. Then, the resulting flux linkage are classified and compared to identify the three phase armature coil of machine in which each phase is separated by 120° phase shift. Furthermore, the flux linkage with the same phase is put together and defined as U, V and W phases. The same procedure is applied in all combinations.

B. Magnetic Flux Linkage

The magnitude of the PM generated flux of outer rotor PMFSM with 12 stator slot and assorted N_r is demonstrated in *Fig. 7*. From the graph, it is clearly observed that the highest amplitude of magnetic flux is obtained for the composition of 12s-14p. So, it can be concluded that the 12s-14p configuration has high probability to produce high torque and power. For the remaining N_r, the value of the magnetic flux is less than the 12s-14p combination.

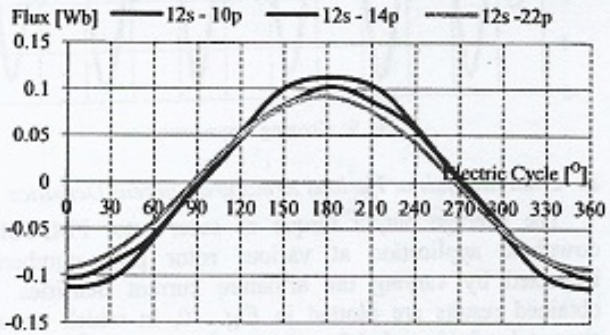

Fig. 7: Magnetic flux linkage of PM

C. Induced voltages at Open Circuit Condition

The induced voltages set up by PM with the speed of 1000r/min at no load condition for different N_r are depicted in *Fig. 8*. It can be seen from the figure that 12s-10p configuration has the lowest value of 199V approximately while 12s-22p combination has the highest value of 355V.

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Moreover, 12s-10p and 12-14p configuration has more distorted waveform compared to 12s-22p and this is by virtue of 5th order harmonic from the initial flux.

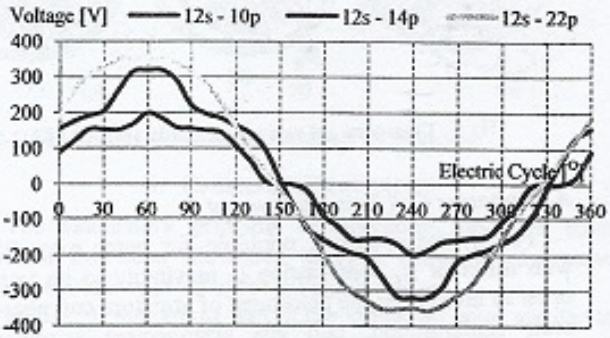

Fig. 8: Induced voltage at 1000r/min

D. Cogging Torque Analysis

The cogging torque characteristic for one electric cycle of different N_r is illuminated in *Fig. 9*. It can be clearly observed that 12s-14p structure has the highest peak to peak cogging torque pursued by 12s-10p configuration with 10.63Nm and 4.92Nm respectively. While for 12-22p composition, the peak to peak cogging torque is about 3.28Nm. Therefore, by employing design refinement methods, the cogging torque of the suggested machine design can be decreased up to an acceptable condition.

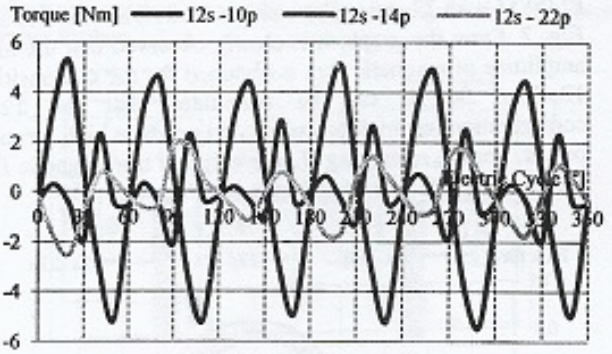

Fig. 9: Cogging torque analysis

E. Load Analysis at Various Armature Current Densities

The average output torque of outer rotor PMFSM for downhole application at various rotor pole numbers is inspected by varying the armature current densities. The obtained results are plotted in *Fig. 10*, in which armature current density is varied from 0A/mm^2 to 30A/mm^2.

It can be observed from the graph that the maximum torque is produced by 12s-22p configuration with approximately 75.59Nm while the minimum average output torque of 41.53Nm is generated by 12s-22p combination. However, for downhole application the maximum armature current density is kept at 5A/mm^2.

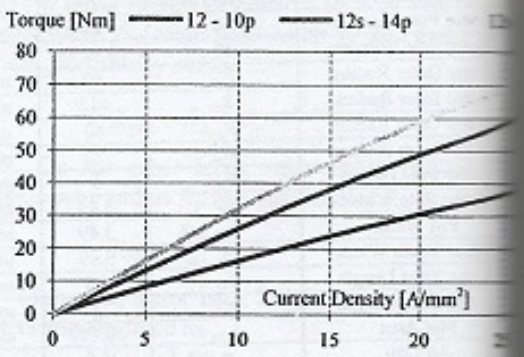

Fig. 10: Average torque at various armature curre

F. Torque & Speed Versus Power Characteristic

For proposed outer rotor PMFSM, the torque versus speed curve at different rotor pole number *Fig. 11* and *12*, respectively. The analysis shows configuration has the minimum base speed of along with maximum output torque of 76.92Nm. this 12s-10p has the highest base speed of 1325 lowest output toque of 41.53Nm.

The maximal power is achieved by 12s-22p that is about 8.95kW while 12s-10p has mini 5.76kW. Additionally, 12s-14p structure has speed of 1190.82r/min with resulting torque of corresponding power is 8.37kW.

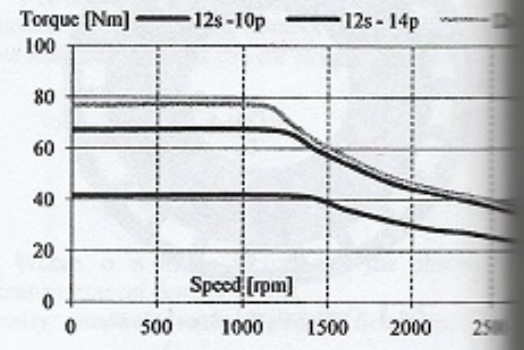

Fig. 11: Output torque versus speed

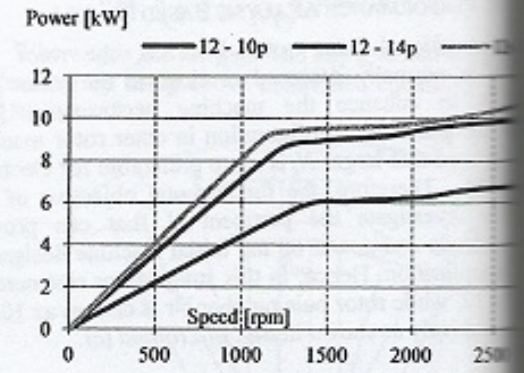

Fig. 12: Power versus speed

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Thus based on 2D-FEA and considering several parameters on machine design, the overall performance of proposed rotor pole combinations is visualized in TABLE. II.

TABLE. II: PERFORMANCE COMPARISION

Number of Rotor Pole	Cogging Torque (Nm)	Maximum Power (kW)	Maximum Torque (Nm)	Speed (r/min)
12s-10p	4.931	5.746	41.53	1325.3
12s-14p	10.636	8.37	67.16	1190.82
12s-22p	3.28	8.95	76.92	1112.15

V. CONCLUSION

In this research work, influence of rotor pole number on the peculiarities of outer rotor PMFSM for downhole applications has been addressed. As the rotor pole number is increased, cogging torque and speed is decreased while increasing the induced voltages, power and torque.

Therefore, it can be concluded from the obtained results that 12s-22p shows a good possibility to achieve targeted goals by employing design refinement and optimizations techniques.

Acknowledgment

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A novel combination notching and pole pairing method for cogging torque reduction in IPMSM and PMFSM.

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***Abstract*— Cogging torque in permanent magnet flux-switching machines (PMFSMs) and Permanent Magnet machine synchronous machines (PMSM) are relatively higher than the other types of PM machines because of their unique doubly salient structure. Reducing the cogging torque in the PMSM and PMFSM is importance to make it as one of the viable alternative to conventional permanent magnet machines. Performances of the cogging torque are comparatively studied in this paper. Percentage difference of cogging torque between these two types of PM machines which are using conventional pole pairing and notching method are highlighted and their maximum torque and power are compared analytically. This paper also proposed a novel method to reduce the cogging torque and thus reducing an acoustic noise, unacceptable vibration and poor positioning control by combining the two methods. Simulation results show that the proposed combination notching and pole pairing method reduces the cogging torque of IPM machine and PMFSM machine by 22.73% and 30.23% simultaneously. The validity of the proposed designed method has been confirmed by 2-D models of the finite element Analysis (FEA) executed in commercial JMAG designer version 14.**

Keywords—Cogging torque, JMAG Designer, Interior Permanent Magnet machine (IPMSM), Permanent Magnet Flux-switching (IPMSM)

I. INTRODUCTION

Permanent magnet (PM) machine has been receiving significant attention especially in electric propulsion system application such as industrial electric drives, electric of hybrid electric vehicles, and wind turbines [1] due to its high efficiency, high energy density per volume unit, high speed operation and high power density capability. However, the undesirable disadvantages of PM machines are the serious distortion of air gap flux density distribution resulting in numerous harmonics in the back EMF, and high torque pulsations including cogging torque and torque ripple [2]. Prior research has also demonstrated that PM machine has significant cogging torque value compared to other type of machines which is mainly caused by the flux density of air-gap is change great [3]. Cogging torque or also called as detent torque and 'no-current' torque is produced by the interaction between permanent magnets (PM's) and slotted iron structure, and manifests itself by the tendency of a rotor to align in a number of stable positions even when not energized [4]. In general, cogging torque unacceptable vibration, acoustic noise, poor po speed control, performance degradation and eve failures. It is a vital design consideration in elec steering, home appliances, robotics, machine spi precision position control and constant speed contr accurate motion control is required [3]. The minimization of cogging torque need to be consid designing for electric motors in practical applicat design-based or control-based techniques are utilized [5]-[7].

However, the available techniques for PMSM and minimize the cogging torque are very limited researched due to the rotor-PM configuration, do nature and high flux density resulting from concentration effects of the circumferentially hous As one of the most widely used techniques, skew can be either continuous or stepwise, is effective t cogging torque and improve the back-EMF Unfortunately, the conventional skewing meth disadvantages of reducing the maximum electromagnetic torque and yielding an unbala electromagnetic force [1]. In this paper, the cogg effect of Interior Permanent Magnet (IPMSM) a can be reduced by applying conventional techni pole notching and rotor pole pairing and also a ne technique which is the combination of both n notching and pole pairing techniques. The differen these two types of PM machines are highlighte cogging torque effect, flux-linkage capabilities, t and power speed characteristics are compared based on the 2D finite element analysis (FEA) designer version 14.1, released by Japan Resea (JRI).

II. COGGING TORQUE REDUCTION TECH

Several techniques used in this paper to minimize torque effect in both type of machines are rotor po rotor pole pairing and a new combination tec

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percentage of cogging torque reduction and machine performance of are compared by a conventional spoke-type 6S-4P IPMSM and 6S-4P PMFSM as illustrated in Fig.1. The design parameter with fixed number of stator slot and rotor pole, stator outer diameter, total permanent magnet weight and a rated speed of 4800rpm is as shown in Table 1 while the materials and condition for all motor models are as shown in Table 2. Rotation motion, torque and arrangement of FEM coil is set under condition setting. Arrangement of the FEM coil are linked with a three phase circuit and a rated speed of 4800rpm is used for magnet and rotor rotation.

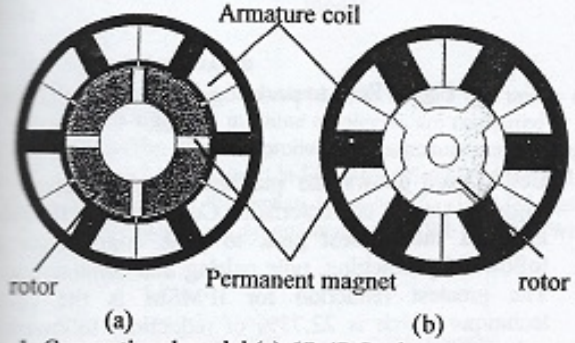

Fig. 1: Conventional model (a) 6S-4P Spoke-type IPMSM (b) 6S-4P PMFSM

Table 1: Design specification of 6S-4P IPMSM and 6S-4P PMFSM

Parameters	6S-4P IPM Motor	6S-4P PMFSM Motor
Stator pole/ slot numbers	6	
Rotor pole numbers	4	
Outer radius of stator (mm)	44	
Stator pole shoes width (mm)	2.1	
Air gap length (mm)	0.5	
Rotor (mm)	15.9	5.0
Inner Radius of rotor (mm))	32.9	15.0
Outer Radius of rotor (mm)	24.6	21.5
Shaft radius (mm)	12.6	5.0
Inner radius of stator (mm)	25.1	22.0
Permanent magnet weight (g)	83	
Stator tooth width (mm)	9.43	5.08
Speed (rpm)	4800	

Parts	6S-4P IPM and 6S-4P PMFSM	
	Materials	*Conditions*
Rotor	Nippon Steel 35H250	Motion: rotation Torque: nodal force
Stator	Nippon Steel 35H250	—
Armature Coil	Conductor Copper	FEM Coil
Permanent Magnet	Neomax-35AH (irreversible)	Motion: rotation Torque: nodal force

Table 2: Material and condition of 6S-4P IPMSM and 6S-4P PMFSM

A. Comparison different techniques for IPMSM and PMFSM

The cogging torque reduction techniques are normally chosen with the conditions of easy implementation, low cost and high machine performances. Three techniques have been used in this paper to reduce the cogging torque effect, which are rotor pole notching, rotor pole pairing, and combination of notching and pole pairing technique. Rotor design for both PM machine with applied cogging torque reduction technique is shown in Fig. 2 and Fig. 3.

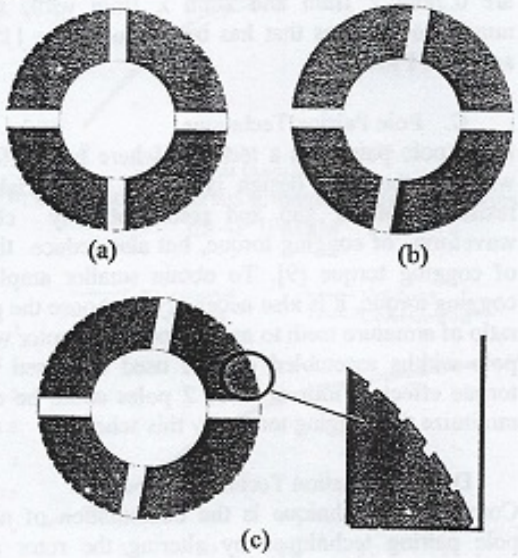

Figure 2: 6S-4P Spoke-type IPMSM (a) Notching Technique (b) Pole Pairing Technique (c) Combination Technique

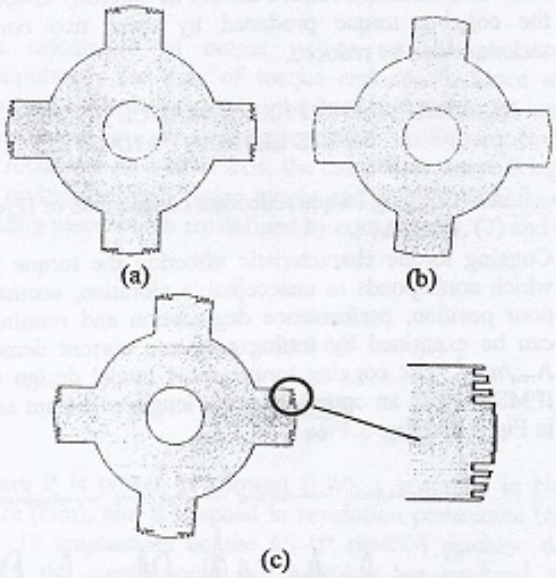

Figure 3: 6S-4P PMFSM (a) Notching Technique (b) Pole Pairing Technique (c) Combination Technique

B. Notching Technique

Notches are dummy slots in either stator or rotor of the machine [8]. This technique can be effectively applied to minimize the cogging torque effect by decreasing the air-gap

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flux. Air-gap flux is directly reduced as the magnet flux density is lowered by changing the magnet grades. Rotor pole-notching will decrease the variation amplitude and increase the variation periods, resulting in a reduced peak value of the cogging torque. Notch depth and width could be carefully chosen as it influences the cogging torque effect. The optimum width and depth values are chosen for both machine are 0.5mm x 1mm and 2mm x 1mm while the optimum number of notches that has been choose are 11 for IPMSM and 6 for PMFSM.

C. Pole Pairing Technique

Rotor pole pairing is a techique where two different size or width in the rotor design is paired. The variable magnetic resistance of air gap and rotor not only changes the waveform of cogging torque, but also reduce the amplitude of cogging torque [9]. To obtain smaller amplitude of the cogging torque, it is also necessary to choose the proper width ratio of armature teeth to magnet pole. The rotor with different pole widths assembled can be used to lessen the cogging torque effect. Width of these 2 poles could be optimized to minimize the cogging torque by this scheme.

D. Combination Technique

Combination technique is the combination of notching and pole pairing techniques by altering the rotor part design. Cogging torque is examined by altering the width of the rotor and the shape of rotor design by putting several dummy slot to the rotor. An optimal number of notching and degree of rotor shifted rotor shaft obtained should be carefully chosen so that the cogging torque produced by these two combination technique can be reduced.

III. RESULT AND PERFORMANCE BASED ON 2D-FINITE ELEMENT ANALYSIS

A. Cogging torque reduction comparison of IPMSM and PMFSM

Cogging torque characteristic affecting the torque pulsation which corresponds to unacceptable vibration, acoustic noise, poor position, performance degradation and running failure can be examined by setting armature current density, J_a=0 A_{rms}/mm^2. The cogging torque for 4 model design of 6S-4P IPMSM with an optimized stack length of 54mm are shown in Fig. 4 and Fig. 5.

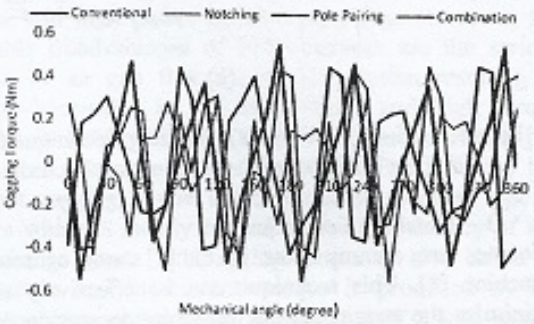

Fig. 4: Cogging torque of 6S-4P IPMSM (Co
Notching, pole pairing and combinatio

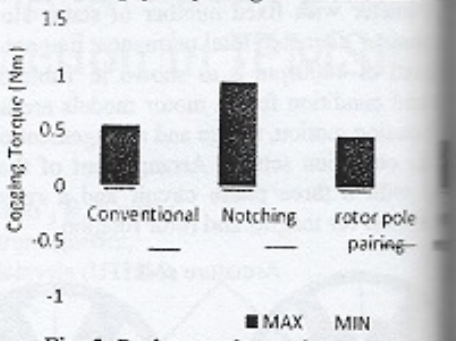

Fig. 5: Peak to peak cogging torque va
model.

Both figure shows the maximum and minim
cogging torque characteristic. Conventional I
indicates the highest peak to peak cogging
followed by notching, pole pairing and combi
The greatest reduction for IPMSM is the
technique which is 22.73% of reduction, follo
pole pairing (15.46%) and notching technique
the PMFSM machine, rotor pole pairing tech
lower percentage of cogging torque reducti
13.955% and another two method indicate the l
peak cogging torque value with highest co
reduction of 30.23%. Fig. 6 shows the comparis
torque value for four type PMFSM mode
conventional model, rotor pole notching, roto
and combination model while Fig. 7 shows the
minimum cogging torque valc for all model
generated cogging torque values must not exce
average torque as it is unnecessary for the perfo
machine that might lead to high vibratio
drawbacks.

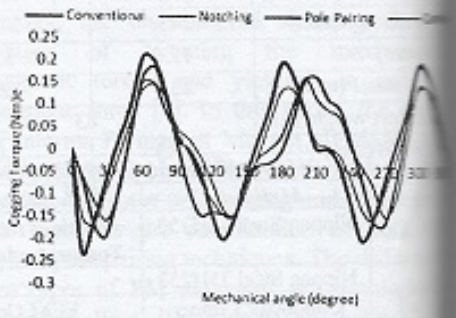

Fig. 6: Cogging torque of 6S-4P PMFSM (Co
Notching, pole pairing and combination

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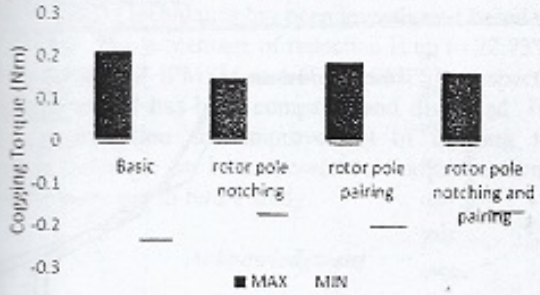

Fig. 7 Peak to peak cogging torque value for PMFSM model.

B. Flux-linkage

The investigations of flux orientation are carried out under open circuit condition where all machine topologies are compared at zero degree rotor position The flux produced by armature current density of Ja=0 Arms/mm2 is illustrated in Fig. 8 for 6S-4P IPMSM and Fig. 9 for 4P PMFSM. All the design technique for IPMSM has the maximum flux amplitude of approximately 0.19Wb and 0.21Wb for PMFSM.

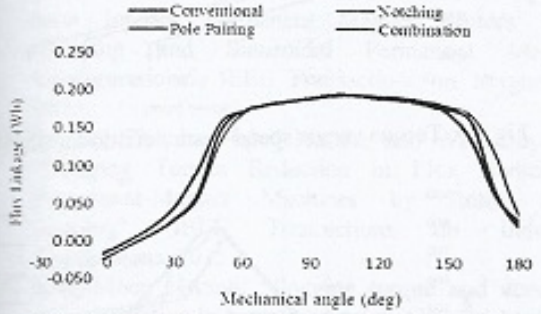

Fig. 8: Flux linkage of Conventional, Notching, pole pairing and combination model of 6S-4P IPMSM.

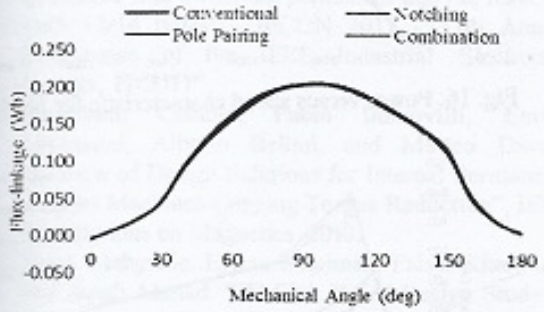

Fig. 9: Flux linkage of Conventional, Notching, pole pairing and combination model of 6S-4P PMFSM.

C. Initial Torque and Power Performances

The resulting data of initial torque performances for four design technique for 6S-4P IPMSM and 6S-4P PMFSM are plotted in Fig.10 and Fig 11. The investigation of torque performances was carried out at maximum armature current densities, J_a=30 A_{rms}/mm^2 for all design machines. IPMSM computed the high performance at 5.48Nm which is 51.28% higher compared to PMFSM (2.67Nm).

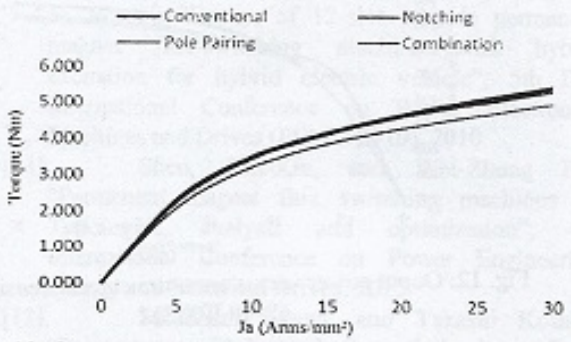

Fig. 10: Ouput torque versus armature current densities, Ja of 6S-4P IPMSM

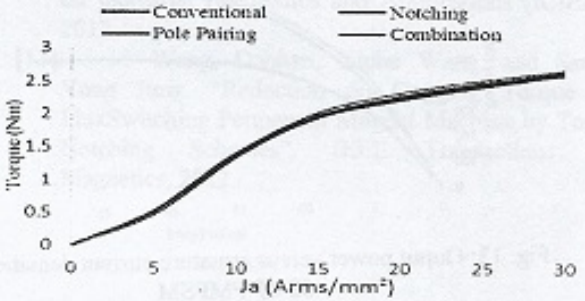

Fig. 11: Output torque versus armature current densities, Ja of 6S-4P PMFSM

The calculation of output power can be executed by manipulating the data of torque and speed. Since all the required data have been obtained in previous analysis, equation (3) is used to substitute them in. Subsequently, for the rotational on a fixed axis, the calculated power is equal to the multiplication between torque and angular velocity of the rotating piece which are defined by equation (1), (2) and (3).

$$P = \tau\omega \qquad (1)$$

$$\omega = 2\pi S\, 60 \qquad (2)$$

$$P = \tau\left(\frac{2\pi S}{60}\right) \qquad (3)$$

Where P is power in kilowatt (kW), τ is torque in Newton metre (Nm), and S is speed in revolution per minute (r/min). Fig. 12 emphasizes on the 6S-4P IPMSM machine design, which the conventional and notching has emerged as the highest machine capability with power of 800W instead of pole pairing and combination model. For 6S-4P PMFSM, Pole pairing and combination model design indicates two times higher power compared to conventional and notching model design.

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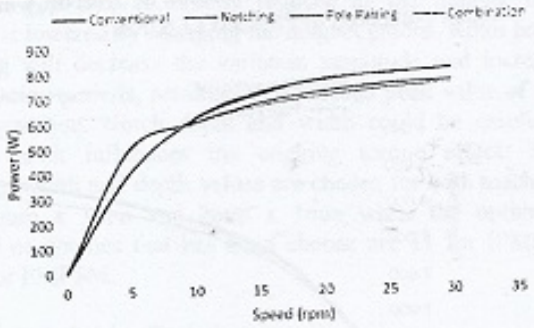

Fig. 12: Ouput power versus armature current densities, Ja of 6S-4P IPMSM

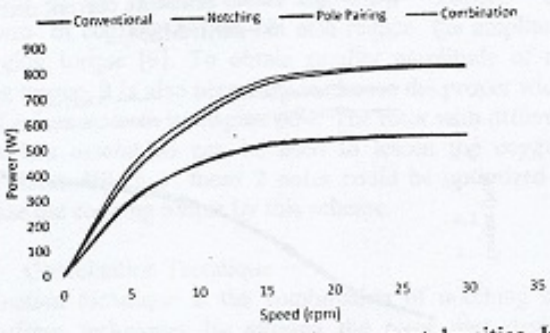

Fig. 13: Ouput power versus armature current densities, Ja of 6S-4P PMFSM

D. Torque and Power Versus Speed

All the torque and power versus speed characteristic of both PM machine design has been illustrated in Fig 14, Fig 15, Fig 16 and Fig 17. The investigation of torque performances was carried out at maximum armature current densities, J_a=30 A_{rms}/mm^2 for all design machines. Conventional model design of 6S-4P IPMSM with an initial speed of 1224.08 r/min resulting the torque of 5.43 Nm with corresponding power reaches 812.74 W. For conventional model design of PMFSM, the initial speed is 1222.95 r/min with the maximum torque of 2.61 Nm and maximum power of 532.21W. As a final point, the overall performances of all proposed model designs are visualized in Table 3 below.

Table 3: Performance comparison of 8 design model.

	Model Design	Cogging Torque (Nm)	Maximum Power (W)	Maximum Torque (Nm)	Speed (r/Min)
IPMSM	Conventional	1.10	812.74	5.43	1224.08
	Notching	0.95	808.45	5.48	1222.98
	Pole Pairing	0.93	764.96	5.32	1182.33
	Combination	0.85	755.07	4.99	1175.76
PMFSM	Conventional	0.43	532.21	2.61	1872.65
	Notching	0.30	527.59	2.61	1864.96
	Pole Pairing	0.37	798.52	2.63	2905.09
	Combination	0.31	807.19	2.68	2924.01

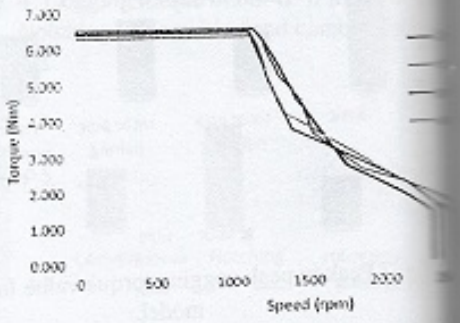

Fig. 14: Torque versus speed characteristic for

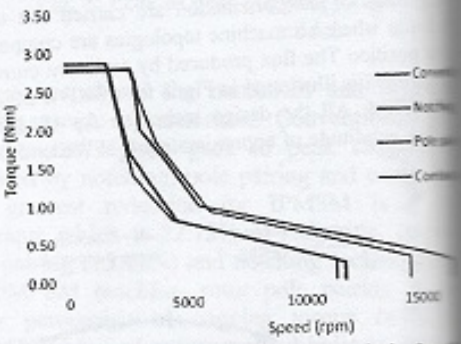

Fig. 15: Torque versus speed characteristic for

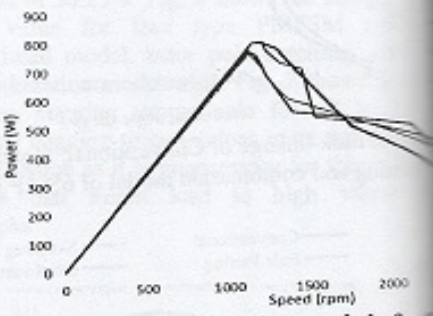

Fig. 16: Power versus speed characteristic for

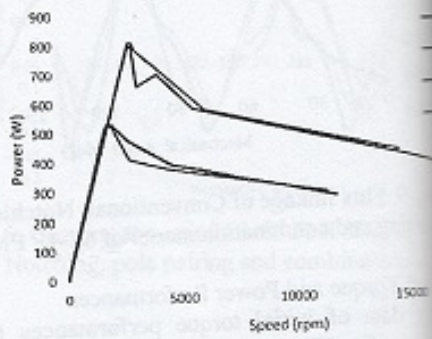

Fig. 17: Power versus speed characteristic for

IV. CONCLUSION

In this paper, the cogging torque effect of sp IPMSM and 6S-4P PMFSM using combinati

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and pole pairing techniques has been investigated based on 2D FEA JMAG. The percentage of reduction is up to 22.73% and 30.23% for 6S-4P IPMSM and 6S-4P PMFSM respectively. All design model has been compared and discussed. Hence, further optimization and improvement of cogging torque reduction technique for better power and torque performance should be carry out in future study.

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High Power Density of Permanent Magnet Flux Switching Machines For Electric Bicycle Application

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***Abstract*—This paper suggests a new design and performance of single phase permanent magnet flux-switching machine (PMFSM) for electric bicycle application. 8Slot-12Pole design machine is selected by analyzing the higher value of power density compare to other topologies. All active parts like permanent magnet and armature coil are located on the stator, while the rotor part consists of only single piece iron. PMFSM have a strong advantage with robust rotor structure that make it much higher power and applicable for EV application compared to SRM and IPMSM. The design, operating principles, characteristics of torque, and power of this new topology are investigated by JMAG-Designer version 14.0 via a 2D-FEA. Size of motor and volume of PM is designed at 75mm and 80g, respectively. Based on the investigation, it can be concluded that the proposed topology of single phase 8Slot 12Pole PMFSM achieved the target of highest performance of power density, approximately at 0.113W/mm^3 with reduced permanent magnet and size of design motor. Due to the low torque performance of this initial design, further works is ongoing to improve the torque performance. In future work, outer rotor PMFSM structure design will be presented and compared with the "Deterministic Optimization Method" to improve the initial design.**

Keywords*—permanent magnet flux switching machine, single phase.

I. Introduction

In over than hundred years, conventional vehicles operate on the principle of internal combustion engine (ICE) which based on fossil fuels have been used for personal transportation. Along with that, the demand of private vehicles has increased every day due to the increasing rates of rapid world populations. Because of the high demand and usage of personal vehicles, ICE automobile becomes a major source of the urban pollutions. Hence, the problems associated with ICE automobiles are three fold, environmental, economical, as well as political. One of the serious problems regarding to the environmental issue is the emissions. The environmental concerns can raise by the increasing pollution levels due to harmful emissions from hydrocarbon fueled power sources [1][2].

Besides air pollution, the other main objection regarding ICE automobiles is the extremely low efficiency use of fossil fuel. In addition, some of the major challenges currently faced in the automotive industry are to cut down the addiction on fossil fuels, reduce the greenhouse gases emitted per km of travel [3].

Therefore, in order to tackle these major issues, auto manufacturers are shifting towards new technologies such as electric vehicles (EVs) and hybrid electric vehicles (HEVs). The concept of EV has been around since the early years of the automotive industry. Since 1910, the EVs have been more numerous than vehicles with ICE. New environmental concerns over the amount of pollutants spilled into the atmosphere each day by ICE have become impressive for the use of EVs. EVs are some of the alternatives for future transportation.

Yet, most of electric vehicles which have been considered were described for electric cars and motorcycles. Another electric vehicle which is also interesting in a wide area is electric bicycle. The electric bicycles have been gaining raising attention over the past ten years due to their reduced energy cost and environmental friendliness [4]. In this respect electric bicycle are enhancing more interesting as they possess of advantage of high energy efficiency compare to other energy forms. Due to the low initial costs, several people wish to use an electric bicycle rather of an electric car or an electric motorcycle [5]. However, there are rarely papers dealing with this application.

The electric motor is key point in deciding component to design an electric bicycle. The type of electric motor and its performance characteristic would be consequential to the overall performance of the Electric Bicycle [6]. There are several category of electric machines generally used in EV for Electric Bicycle application, such as Multi-Flux Permanent Magnet (MFPM), Switch Reluctance Motor (SRM) and also Permanent Magnet Synchronous Machines (PMSMs) [7], [8], [9]. Nevertheless, there exist several imperfections in each motor such as low power, low torque, high volume of permanent magnet (PM), and noisy which is not desirable in this application.

Furthermore, the cost of PM in PMSM is expensive and this would raise the price of the vehicles. Although Interior Permanent Magnet motors are developed to overcome these drawbacks but there are certain problems such as design motor are more bigger, low power and torque density[10] and number of phase make the motor more complex structure to design which is not desirable for this applications[5].

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Electromagnetic Performance of 12S-14P Outer Segmental Rotor Permanent Magnet Flux Switching Motor for Electric Scooter Drives

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Abstract- Electric motor in an outer rotor configuration is employed for in-wheel drive application. Permanent magnet flux switching machine (PMFSM) has become an attractive area of research because PM ensures no-loss excitation. Due to economic and environmental issues in the area of saving cost and protecting the environment from gas emission, electric motors do not use fuel oil for propulsion. They are powered by electric motor using rechargeable battery current. The initial design of this motor using segmental rotor has been proposed. Presently, surface mounted PMSMs have been installed in electric scooters with base speed of 100km/hr and power output of 6kW. However, this power is not capable of sustaining scooter's speed for long distance travel. This paper presents the performance characteristics of a new 12slot-14pole segmental rotor PMFSM that is capable of delivering seven times the power of conventional eclimo electric scooter for long distance travel. Analysis and simulation are done using 2D-FEA released by JMAG Designer version 14.1. Furthermore, the motor's performance in terms of flux linkage and distribution torque characteristics, speed and power output are investigated. Result shows the average torque of 168Nm with power of 18kW which is three times more than conventional eclimo electric scooter.

Keywords- In-wheel drive; outer rotor; segmental rotor; PM excitation; loss-free excitation; flux switching motor; electric scooter and electric motorcycle.

I. INTRODUCTION

In the transportation sector, electric motorcycles are the most practical solution for road decongestion in the increasing population and eliminating gas emission from urban cities [1-4]. This zero emission electric motorcycle is reliable for delivering greater efficiency and performance. Furthermore, it has the potential for dominating the future vehicle market as it is sold for less money than cars [5]. These electric vehicles are propelled by electric motors which are powered by electricity stored in a rechargeable board [6]. The motors convert electrical energy stored in the battery into mechanical by providing torque and speed voltage which enable mechanical activity such as forward driving operation to be executed. Torque and speed being the two main key characteristics desired for electric motor operation, others include high torque density, high power with high efficiency [7-9]. Two machines have been considered as viable candidates for electric scooter in terms of high power and efficiency ratings namely permanent magnet direct current (PMDC) motors and surface mounted permanent magnet synchronous motors (SPMSMs) shown in Figure 1. However, investigations into these motors, DC requires high maintenance due to the existence of mechanical split rings and brush. Again, motors are huge in size, low efficiency and low reliability, making it unsuitable for long distance travel [10]. SPMSM on the other hand, risks rotor's robustness due to the surface mounted PM which reduces efficiency at high speed [11]. Hence, research to solve the challenges is necessary.

The PM flux switching motor (PMFSM) is one of the three categories of flux switching motors with electrical frequency twice that of conventional synchronous motors. In fact, FSMs have all active parts located on the stator leaving the rotating rotor robust [12]. Advantages of PMFSM include free-loss excitation, less space occupation, higher torque density, easy cooling of all active parts and favorable for high speed operation [13].

Since the discovery that electric motors could aid vehicle propulsion, researches have not been focused on exploring the segmental rotor which has the advantage of short flux path and higher torque [15].

To ensure further attractive characteristics, outer segmental rotor PMFSM with 12slot-14pole using external envelop for direct fabrication with sprocket has been proposed as illustrated in Fig. 2. Generally, the motor is composed of 12 PMs and 12 armature coils in concentrated winding arrangement. The three phase armature coils are accommodated in 12 armature slots for each one-fourth stator body periodically. As the rotor rotates, the fluxes are generated by PMs with armature coils. Furthermore, for the rotor rotation through 1/14 of a revolution, the flux linkage of the armature coil has one periodic cycle and the frequency of induced back-emf in the coil becomes fourteen times of the mechanical rotational frequency [16].

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Forecasting with Limited Data Using Fuzzy Random Auto-Regression Model

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Abstract. **The statistical models required the large data size in the time series forecasting. While, to forecast the limited data or small data cannot be suggested by using these models. In this paper, we are interested to apply fuzzy random auto-regression model to handle this type of data. The accuracy of the confidence-interval can be improved through the left-right spreads of triangular fuzzy number. The yearly enrollment data of Alabama University are examined to evaluate the performance of proposed model. The results indicate that the smaller left-right spread of triangular fuzzy number produced the higher forecasting accuracy if compared with base line spreads.**

***Index Terms*—Confidence interval, fuzzy random variable, auto-regression, enrollment**

I. Introduction

Statistical models often require some assumptions on the data size, the normality of data set, etc., especially when used in the forecasting. In conditions where the data are not normally distributed and have limited number of observations (number of sample ≤ 30), conventional statistical models cannot be suggested to forecast these data. Moreover, when the data set are presented in the linguistics type, then they also cannot be forecasted by statistical models. To solve these problems, the non-probabilistic models, such as, the fuzzy time series [1-4], fuzzy regression [5,6], fuzzy random regression [7,8], and fuzzy random auto-regression [9] were introduced by researchers, since the models do not require strict assumptions.

The forecasting with limited data are frequently used for long-term period, such as, yearly data, or more than one year. Additionally, this data type is not easy to collect by researchers because they will take time in providing. For example, the university enrollment data, the gross national income (GNI), the gross domestic product (GDP), others. On the other hand, these samples data need to be estimated for their future planning and developments. Therefore, the appropriate forecasting models should be considered also. In this paper, we implement the fuzzy random auto-regression model (FR-AR) to forecast the limited data, namely, enrollment of Alabama University from 1971 to 1992. To obtain the better forecasted values, we improve the forecasting accuracy through left-right spreads (LRS) of triangular fuzzy number (TFN).

II. The Basic of Fuzzy Random Auto-regression Model

A. Fuzzy Random Variables

Given some universe r, let *Pos* be a possibility measure that is defined on the power set $P(\mathrm{r})$ of r. Let R be the set of real numbers. A function $Y : \mathrm{r} \to R$ is said to be a fuzzy variable defined on r [10]. The possibility distribution μ_Y of Y is defined by $\mu_Y(t) = Pos\{Y = t\}$, $t \in R$, which is the possibility of event $\{Y = t\}$. For fuzzy variable Y, with possibility distribution μ_Y, the possibility, necessity, and credibility of event $\{Y \le r\}$ are given as follows:

$$Pos\{Y \le r\} = \sup \mu_Y(t),\ t \le r, \tag{1}$$

$$Nec\{Y \le r\} = 1 - \sup \mu_Y(t),\ t \ge r, \tag{2}$$

$$Cr\{Y \le r\} = \tfrac{1}{2}(1 + \sup_{t \le r} \mu_Y(t) - \sup_{t \ge r} \mu_Y(t)). \tag{3}$$

From Eq. (3), we note that the credibility measure is an average of the possibility and the necessity measures, i.e., $Cr\{.\} = (Pos\ \{.\} + Nec\ \{.\})/2$. The motivation behind the introduction of the credibility measure is to develop a certain measure, which is a sound aggregate of the two extreme cases, such as the possibility (which expresses a level of overlap and highly optimistic in this sense) and necessity (that articulates a degree of inclusion and is pessimistic in its nature). Based on credibility measure, the expected value of fuzzy variable is presented as follows.

Definition 1. Expected value of fuzzy variable [11]

Let Y be a fuzzy variable. The expected value of Y is defined as:

$$E(Y) = \int Cr\{Y \ge r\}\, dr - \int Cr\{Y \le r\}\, dr, \tag{4}$$

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Prediction of Student Final Grade by using k-Nearest Neighbor Algorithm

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***Abstract*—Assessment is the most important part in learning activities. Student accomplishment determined based on achievement of the final grade on particular course. There are many grading system have been developed to support academic process work effectively and efficiently. The student's recorded grade in prior semester can be used to predict student achievements in next semester. This research is conducted to employ a classification algorithm that applied to predicts student final grades. This research proposed k-Nearest Neighbor (k-NN) algorithm. k-NN is a classification algorithm that works by measure the distance of current student grade to all prior semester grades. The result of this study will be deployed in iAsist system that was built to manage student grade, also called as Student Grading System. This study analyzes 782 student grades data in Politeknik Caltex Riau that have been collected since 2013. This algorithm reach 70.15% accuracy. In addition, the accuracy was evaluated from 156 sample data (testing data). The conclusion of this research is k-NN Algorithm can be applied to predict student final grade based on past semester final grades.**

Keywords—classification algorithm, final grade, k-NN

I. INTRODUCTION

In early 2000, technology has been developed rapidly. There are many information system have been created to support the business process of an organization. Each organization participated to use and adapt several technology to ensure sustainability. Higher Education become an organization was adapted and implemented technology. Almost all higher education employ management system to manage their academic process by using internet. One of the most applied system known as Academic Information System. Academic Information System used to manage student data and record others important data such as: presence, grading, courses, etc. There are many data have been collected and stored in academic information system. That stored can be used to discover many information related to academic process, especially student grade.

Discussion of grading method, in higher education, an institution using a certain mechanism to record and evaluate student grade. Based on Peraturan Pemerintah Nomor 19 tahun 2005 [1], grading system is a method that was conducted to evaluated academic process continuously. All of student grade has been recorded for each semester. Recorded grades will be used to generate the GPA for each student and analyze higher GPA for each semester. The data also used to generating the average GPA to measure institution achievements.

There are many new information can be discovered from grading data in academic information systems. Discussing new information discovery, data mining is the most popular approach. Data mining is study that applied to analysis and discover new information from large amount of data. The information is generated by using particular method and algorithm. Appropriate method must be defined based on information that will be gained. In data mining, supervised learning is a method that used to predict and estimate information based on past data. There are many algorithm included in supervised learning, such as Naïve Bayes, Decision Tree, Nearest Neighbor, Neural Network Support Vector Machine, etc.

Nearest neighbor become a popular algorithm for numeric data. Related to grading data (numeric data), nearest neighbor is appropriate algorithm. Grading data can be used to predict student final grade by applying nearest neighbor algorithm. This research conducted nearest neighbor algorithm by define the number of k. This algorithm is called as k-Nearest Neighbor (k-NN). This research aim to predict student final score in particular course by using past grading data. The result of this research will be used as a model to predict student final grade in higher education and will be applied in Student Grading System.

II. RELATED WORKS

There are many researches have been applied data mining in education, especially in grading system. The study uses a variety algorithms. Research conducted by [2] produces the recommenders system that is used to find the necessary teaching materials. Recommended learning resources result was generated by analyzing behavior of student interaction when learning process. This study did not implement certain classification algorithms, but the result of recommendations resulting processed based on the behavior of students while using the system. Research conducted by [3] design decision support system that is used to predict the student final scores in calculus course. Data mining algorithms used is Bayesian Relief Network. The accuracy of the prediction results achieved 82.6%.

National Defence University of Malaysia (NDUM) has been using data mining techniques to develop the assessment system

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Analysis Reliability Distribution System Uses The Method of Reliability Index Assessment (RIA)

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***Abstract*— Reliability can be seen the extent to which electric power can supply continuously in one year to consumers. This research aims to know the index of the reliability distribution system network 20 kV at PT PLN (Persero) Rayon Panam Pekanbaru Feeder 12 Kualu. The calculations and analysis use RIA (Reliability Index Assessment) method, the first analysis, system is assumed in perfect switching condition, and the second in imperfect switching. Based on calculation and analysis, the conditions in perfect switching, the value of SAIFI 0.30 times/year, SAIDI hour/year 1.19, CAIDI 6.63 hours/year. the conditions in imperfect switching, the value of SAIFI 0.63 times/year, SAIDI 4.19 hours/year, CAIDI 6.65 hours/year. Thus the distribution network feeder 12 Kualu still reliable. The value of SAIFI and SAIDI is smaller than specified by PLN. Based on standard PLN for the value are SAIFI 3.2 times/year and SAIDI 21 hours/year.**

Keywords*— *index of the realibility; distribution system, RIA method, perfect switching, imperfect switching

I. INTRODUCTION

Demand of Electrical energy from year to year increasing in line with the growing needs of the economy and the welfare of society. The growing demand for electrical energy is balanced with the need to improve the power generation and the capabilities of infrasturucture, resulting in the distribution of electrical energy to consumers goes well with the quality of the distribution of electrical energy that meets the standards. In electric power distribution system, the level of reliability is the most important thing in determining the performance of the system. Reliability can be measured by the extent to which electric power system could supply energy to the load in one year. Disruption or damage of electric power distribution system will affect the value of the reliability of the distribution system [2].

To be able to determine the level of reliability of a system, it must be held by way of examination through a calculation as well as the analysis of the success rate of the performance or operation of the system. There are three basic parameters in reliability that can be used to evaluate the radial distribution systems i.e. number average failure (λ), the average extinguishing time (r), and the annual extinguishing time (U).

In the analysis of the reliability of the distribution network of 20 kV, to determine the level of possibly the author uses the method of Reliability Index Assessmen (RIA) which is an approach to predict the failure of distribution system based on the topology of the system and the data concerning the reliability of the components. RIA method logs a failure that occurred on the equipment in a comprehensive manner, and then identify the failure so that the resulting reliability indexes that include the system Average Intruption frequency index (SAIFI), system Average Intruption Duration index (SAIDI), Customer Average Intruption Duration index (CAIDI) [2].

II. RELIABILTY OF RIA METHOD

A. Reliability of Distribution System

Electric power distribution system of functioning distributed electric power to the constumer through a network of low voltage, whereas a transimi channel serves to channel the extra high-voltage power ke load centers in the great power (via the distribution network) [7].

Reliability is the success rate of the performance of a system or part of the system, to be able to give better results in a period of time and in certain operating conditions, determine from a system, the examination should be held by way of calculations or analysis of the success rate of the performance or operation of the systems reviewed, in a certain period and then compare it to the previous standards established [4].

There are a few things to know before calculating system reliability index that is by knowing the value of equipment reliability data. These data were obtained from the SPLN 59 in 1985 for equipment reliability data [12]. As shown in TABLE 1. Index of reliability on radial SUTM SPLN 68-2 in 1986 where for SAIFI was 3.2 times/year and SAIDI of 21 hours/year [14].

TABLE 1. DATA RELIABILITY EQUIPMENT

Equipment	Failure Rate	Repair Time
Circuit Breaker	0,004 failure/unit/year	10
Overhead System	0,2 failure/km/year	3
Distribution Transformer	0,005 failure/unit/year	10
Recloser	0,005 failure/unit/year	0,25
Underground System	0,07 failure/km/year	

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Forecasting Consumer Price Index of Indonesian Using Holt's Exponential Smoothing

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Abstract—**In this paper, the Holt's exponential Smoothing model were used to forecast inflation rate of Indonesian using the monthly consumer price index (CPI) data from January 1996 to June 2016. Results show that the Holt's exponential smoothing is suitable for forecasting CPI and subsequently the ifnflation rate. The choice of the Holt's exponential smoothing is good, because the smaller deviations in the mean absolute percentage error and mean square error. Moreover, the Holt's exponential smoothing model is less complicated since you do not require specialised software to impement it as is the case for ARIMA model. Forecasting data was only used the R programming language. The forecasted inflation rate for July and August, 2016 is 2.8 and 2.7 respectively.**

Keywords—Holt's Exponetial Smoothing, Forecasting, Consumer Price Index, Means Square Erroe and Mean Absolute Percentage Error

I. INTRODUCTION

According to Ref. [1], inflation is a persistent rise in the general price levels of goods and services in an economy over a period of time. Inflation has been one of the most economic challenges in the world, especially in developing countries. Indonesian has been facing this challenge for so many years now. Keeping inflation at a low level has been one of the major goals of economic policymakers around the globe. The maintenance of price stability is one of the macroeconomic challenges that the Indonesian government has been facing since its independence which is now 71 years ago.

Indonesia's overall economic performance has strengthened since mid 2001 after two decades of high inflation and low economic growth, reflecting sharply improved fiscal and monetary policies and progress in structural reforms. Having achieved single digit inflation, Indonesia will need to consider how best to manage monetary policy in a low moderate inflation environment. Under the authorities' current regime, based on monetary targeting and exchange rate flexibility, monetary and fiscal restraint successfully reduced inflation. The Indonesian authorities plan to reform their monetary policy framework. They are considering a gradual shift from strict monetary targets to a framework that would use interest rates as the main instruments to anchor inflationary expectations, perhaps leading eventually to an explicit inflation targeting regime. While inflation has been reduced under the current framework, the authorities remain concerned about persistently high bank lending rates [2].

The proposed research study actually intends to model long term behaviour of monthly inflation rate data of Indonesia from January 1996 to June 2016 and predict future values. This research study actually attempts to provide information to policy makers to enable them make better decisions about the future and increase to the existing human stock of knowledge from which will be able to generate new insights and ideas about inflation.

II. METHODOLOGY

Holt's Exponential Smoothing

Holt's exponential smoothing is another modeling technique (not based on the ARIMA approach) that uses only a linear combination of the previous values of a series for modeling and generating future values. Given that only previous values of the series of interest are used, the only question remaining is how much weight should be attached to each of the previous observations. Recent observations would be expected to have the most power in helping to forecast future values of a series [3].

Let $Y_1, Y_2, \cdots Y_n$ be a set of observatioans on a non-seasonal time series. The Holt's exponential smoothing forecast is based on the assumption of a model consisting of a trend. We use the following procedure to forecast non-seosonal series.

1. The first step is to obtain the level estimate and trend estimate represented by $\hat{Y}_t$ and T_t respectively as

$$\hat{Y}_t = Y_2, \qquad T_2 = Y_2 - Y_1$$

These can also be estimated by fitting a least squares trend line to haf of the historical data. Here y intercept is A_0 and slope is T_0

$$A_t = \alpha Y_t + (1-\alpha)(A_{t-1} + T_{t-1}) \quad (0 < \alpha < 1; t = 1.2.\cdots, n) \quad (1)$$

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The Ethno-mathematical Study in Acehnese Culture (The Traditional Dances Analysis from Tanah *Rencong*)

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Culture cannot be avoided in everyday life.It is a unified whole and the overall prevailing in a community, including Langsa, Aceh. This enables the mathematical concepts embedded in cultural practices and recognizes that all people develop a special way of doing mathematic activities called ethno-mathematics. This study aims to describe the results of ethno-mathematics investigations by the ethnographic approach application in local cultural products of Langsa, Aceh. The data were obtained from literature studies, observations, interviews, and documentation. The results indicated that that without acknowledged the mathematical concept, the local community in Langsa, Aceh has implemented the concepts in their daily lives using ethno-mathematics. It proved that the existence of ethno-mathematics forms in Acehnese society. It reflected through various cultural activities and products. These activities and products covered on cultural heritages, i.e. the structure of *Rumoh Aceh*. It formed geometric shapes on the buildings construction parts, including the flat-figure model, covering square, rectangular, and trapezoid. In addition, it also covered triangle, isosceles triangle, equilateral triangles, pentagons, and lozenges. These are the geometrical model in mathematical concept. Thus, the researcher concurredin three suggestions. The suggestions are (a). It is essential to introduce these cultural activities and products as the alternative mathematics geometrical models that come from the outside of classroom, (b). It is important that to introducethese cultural activities and products in formal mathematics learning process as the new way to teach the students about the concept of mathematics geometrical model that existed in local community. (c). It is prominent to be applied as material reference for mathematical problem solving question models.

Keywords:*Ethno-mathematics, Culture, Mathematics,* and *Contextual.*

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A. The Background of Study

Aceh one of Indonesian provinces, located on 5°33'N 95°19'Ewith 57.365,57 km² range covers. Back in 2002, Aceh still has 13 regional states. Then, in 2007, it is extended into 23 regional states and 5 city-states for the whole, as the dynamic growing of local social politics; with own less than 4 million citizens.[1] This certain condition influences various aspects in Aceh local society; i.e. local people, educations, politics, economics, and cultures systems its selves. Thus, culture is one of influence aspects, massively functioned both people and society.

Traditional dances are culture products. Yet, Indonesia has colorful dances, spread over provinces and Aceh as well. The dances not only serve as local culture symbols, but also the reflection of dominated religion. Furthermore, dances own mathematical symbols, such as numerical patterns, which the patterns have esthetical values. Thus, it is observed on ethno-mathematical disciplines.

Ethno-mathematical is defined as specific way to be applied on cultural scholar on mathematical activity. The activity is the abstracted process from real daily experiences into mathematical activity, or vice versa. It is included classification, measurements, designing the tools, patterns, equations, location taking, playing, explanations, and so on. In additions, Ethno-mathematical patternsexist on local Sidoarjo people. It is taking on mathematical ancient temples, epigraphs, vessels, traditional utensils, local measure systems, batik patterns, embodied, and local plays.

The portion of ethno-mathematical can be settled on art subject on educational institution. The education institutions layers on elementary, junior high, senior high school, and higher education. Moreover, the elementary school is the former place where dances are introduced to the students. Then, to support its introduction process, there are three components, which are categorized important to be highlighted in education, i.e. moral favor (affective), knowledge (cognitive), and physics (psychometric). These components should be move along, without overlapping

[1]BadruzzamanIsmail, *Sistem Budaya Adat Aceh dalam Membangun Kesejahteraan*, Banda Aceh: MajelisAdat Aceh. 2008, P. 1

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ARABIC CHARACTER RECOGNITION USING LEARNING VECTOR QUANTIZATION

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ABSTRAK **– Arabic character recognition should be research again. Arabic character have 28 characters with 4 different positions in sentence, then Arabic character has 28-100 characters. The method is used for Arabic character recognition is learning vector quantization neural network. It is because, the learning vector quantization could classify input in category defined on training network. The objective of this study is to testing LVQ method in Arabic characters recognition. The experiment conducted using all types' position of character in sentence, there are isolated, begin, middle, and end. The testing data of Arabic character passed preprocessing phase to get vector number that was the size of matrix is used as input for learning vector quantization. The size of matrix was 8x10 for isolated, middle; end and 7x12 for begin. The success accuracy rate for isolated was 76, 43%, begin was 65, 45%, middle was 62, 73%, and end was 80%. The success accuracy percentage for all Arabic character was 72%.**

Keywords: Arabic Character, Character Recognition, Learning Vector Quantization, Size of Matrix, Success Accuracy.

I. INTRODUCTION

Pattern recognition is a technique used to classify an object by main feature or main properties [1]. Pattern recognition done by identifying pattern in an object on one of group. Pattern recognition can be done on characters of letters.

A letter is smallest unit or smallest information from a sentence that needs to be defined so that information on a sentence could understand. A letter have different form between one another, to distinguish it adapted characteristic one of the letters [2]. The letters have differences pronunciation, although the letters have same characteristic. One of the letters has difference characteristic and pronunciation is Arabic character.

Arabic characters have 28 difference characters between one another. Arabic characters have difference characters in accordance with position on a sentence. Parts of Arabic characters have 4 form differences position on sentences, another part of Arabic characters have 2 form differences position on sentences. Therefore, Arabic characters have 28-100 characters, with addition of changes in the form characters. Difference characters will change if the characters on isolated, begin, middle and end [3].

Learning vector quantization (LVQ) was introduced by Tuevo Kohonen, who also introduced Kohonen method. LVQ is one of artificial neural network and supervised network. LVQ classify input in category that has been defined through supervised network (Putra, 2010). On research which title Difference between Kohonen Neural Network and Learning Vector Quantization on The Real Time Handwritten System have purpose that recognition with LVQ better than Kohonen in terms of accuracy.

Another research entitle Analysis and Implementation of the Kohonen Neural Network for Arabic Character Recognition [5], featuring error result of experiment kohonen neural network. On that research, the error result was 43, 64% on begin of Arabic characters. In this study, used LVQ method decrease the error of Arabic character recognition. Based on [5] and this study same in Arabic characters, there were begin, middle, end, and isolated. But different in site of matrix image of Arabic characters. In this study found best practice for matrix image have various size. It was 8x10 for isolated, middle, and end, 7x12 for begin of Arabic characters.

II. CHARACTER RECOGNITION

Almost all type of character recognition use the same phases to recognition the characters. Generally, procedure to character recognition is used by many researches [5].

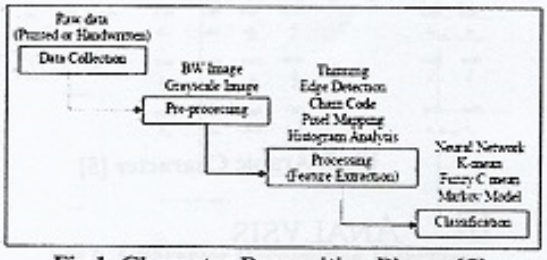

Fig 1. Character Recognition Phases [5]

On this research, Arabic character recognition using learning vector quantization phases in figure 2:

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LEARNING DEVELOPMENT BASED ON ANDROID MOBILE ON SUBJECT INFORMATION AND COMMUNICATION TECHNOLOOGY

(Case Study for Class X Senior High School -SMA)

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Abstract— This study aims to determine the validity, practicalities and Effectiveness Design and Manufacturing Media Learning On Android-Based Mobile Device Subjects Information and Communications Technology Class X Odd Semester at Senior High School (SMA). This research is the kind of researcher's and development (Research & Development). Data is collected to users of Android-based learning media. These samples included 31 people consisting of 30 students and 1 teacher ICT SMA.Based on the research that has been done, the obtained results in terms of aspects of validation if (1) The subetance Material: 86.66%; (2) Dcsign for Learning: 94.99%, (3) Display Visual Communications 81.96%; (4) Utilization of Software 81,71%. Overall assessment validator test instructional media on mobile devices based on Android ICT subjects in class X SMA amounted to 86.33%, so that the level of validity can be interpreted **Valid to used.** While the results of the test vote practicality in terms of aspects (1) Circumstances of Use (attract): 91.16%; (2) Effectiveness of Learning Time: 93.23%; (3) Benefits: 91.78%. Overall assessment of the practicability test instructional media on mobile devices based on Android ICT subjects in class X SMA amounted to 92.06%, so the level of practicality can be interpreted **Very Practical to use.** The results of testing the effectiveness of assessment in terms of aspects (1) Glad learning: 90.87%; (2) The existence of Interesting Subjects: 84.38%. Overall assessment study testing the effectiveness of the media on mobile devices based on Android ICT subjects in class X SMA amounted to 87.63%, so the level of effectiveness can be interpreted **Highly Effective use.**

Keywords — Learning Media, Mobile Devices, Andorid, Adobe Flash CS 6, Action Script 3.0, Information and Communication Technology

I. Introduction

Learning can be viewed as a process that is directed towards meeting the objectives and the process of doing through a variety of experiences that created the teacher. According Sudjana (1989: 28) is also a process of learning to see, observe, and understand something. Learning activities carried out by two actors, namely teachers and students.Behavior of teachers is to teach and the student's behavior is learning.

Entering the era of Information and Communication Technology, strongly felt the need and importance of the use of technology in the learning activities to improve the quality of learning expected.

The development of mobile devices is the development of technology weapons very rapidly at this time, one of which is a mobile phone (cell phone / mobile phone). At this time the phone is already highly developed so as to have a wide range of capabilities such as access to internet and also have operating systems like computers so often called smartphones. Utilization of smartphone capabilities for multiple purposes in the field was developed with apps -applications that are capable of supporting in its use. Including the use of a smartphone 's usability study media

Smartphone technology is one that can not be separated from daily life - today. Besides easily accessible, the smartphone is also easy to use anytime, anywhere and on virtually all societies are now able to operate the smartphone. The operating system is currently very popular is the android operating system. Lots of vendors or companies electronics companies, particularly in the field of

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VIRTUAL WORLD ENVIRONMENT DESIGN FOR VIDYANUSA E-LEARNING SYSTEM

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Abstract— **Increasing interest in exploration of virtual worlds has lead to the creation of hundreds of such environments and it's expansion especially in the field of education. A large number of research have focused on analyzing experiences of the use of this virtual worlds environment to the need of education. Instead of research to the design and production process of the virtual world and how it use is still relatively minimal. The purpose of this study was to design a virtual world environment and identify important themes in it according to the needs of teacher and student at this time, with the aim of assisting the teacher as information providers and educators as well as student make the learning process more fun. Model of virtual world environment are design as a product of this research.**

Vidyanusa e-learning system is a system that quite complex because of many themes include learning activities and subsystem to support the collaboration of the themes events. Therefore, to realize the implementation of this system, will required support from all sector of society, equitable dissemination, and use of ready use resources. Virtual world environment model are made considering of priority themes of the learning process derived from some teacher of junior highschool (SMP) in Bandung. This model explains the role of virtual world environment which differ from teacher, provide ideas and creativity on students, and suggestions for effective and efficient learning process. It can be used as starting point or as a checklist for planning and producing and ideal educational system. With some modification, the modeling process can be used in other case of virtual world environment as well. The introduction of vidyanusa e-learning system using new technologies as medium of teaching and learning, is expected to improve the quality of human resources of its most important life-phase which is the initial phase of formal education and disipline.

Keywords— **virtual world, digital media, education, vidyanusa, educational game, crayonpedia, thematic learning, math, junior high schools.**

I. INTRODUCTION

Computer based learning games has enters a new exciting and promising era. Games with serious impact on society (eg: education, e-learning and simulation) popping up on the market with varying quality. Many people who work in the field of education try to make their own games. Its main task is to design a game based learning system that change the responsibility of the teacher from informant becoming a supervisor who analyze every activity and behaviour of the student in the game, to improve the effectiveness and efficiency each student to understand the core of each lesson.

Vidyanusa Education System using gamification in building a learning tool for student in particular, but also can be used by all people whether it comes from the field of education (teacher, parent, expert) as well as from non-education, which each have role in the games. Vidyanusa Education System is purpose-built learning tools that can make positive transformation of education system in Indonesia, which is :

1. Faster learning time
2. Capacity for more users
3. Standardized content
4. Better learning quality
5. Universal use

Vidyanusa e-learning system is used in the development of educational game because of the balance of its game elements (*identity, immersion, interactivity*) and pedagogy elements (*increasing complexity, informed teaching,* dan *instructional*).

II. BACKGROUND

In 2012 Program for International Student Assessment (PISA) (in Ibas, 2013) in the survey mentioned that the ability of mathematics students in Indonesia was ranked 64 out of 65 countries.

Fig. 1 PISA survey result for mathematics in 2012

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Prediction of Divorce Case Ruling Using Naïve Bayes Classifier

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***Abstract*— Divorce data in Indonesia continue to increase every year. Although the data have important value which has potential to be a basis of research, these have not been used for a study based on information technology. In addition to the rapid advancement of technology, data mining is a solution in the world of information technology for appropriate, accurate and efficient information taken from a set of dataset. This study aims to build a model by applying Naive Bayes classifier for predicting divorce case decision based on training data. Data which used to build a predictive model are the divorce case downloaded from the Religious Court of Pekanbaru website in 2014 and it was amounted to 702 records. These data will be processed by using Naïve Bayes Classifier. We extracted information and new patterns based on historical data to predict the verdict of a divorce case. The results of the classification model analysis were implemented on web-based system. The system was tested using Evaluation and User Acceptance Test. It showed that the built system is able to help prospective users to face a divorce case with the highest degree of accuracy is 95,714%.**

Keywords*— *Data Mining; Naive Bayes Classifier; Divorce Case; Prediction; Machine Learning

I. INTRODUCTION

The divorce rate in Indonesia continues to increase dramatically. Bureau of Religious Courts, part of Supreme Court of Indonesia, recorded during the period 2005 to 2010, the divorce case increased of up to 70%. Directorate General of Supreme Court, Wahyu said that since 2005 the divorce rate continues to rise above 10% annually [1]. Supreme Court's data in 2010 reported that during 2005 to 2010, or an average of one out of 10 married couples ended up divorce in court. Even in 2012 and 2013 the divorce rate in Indonesia was the highest in the Asia-Pacific [2]. Data from Administration Information System of Religion Court that can be seen on the site perkara.net, from 2011 to 2015 there have been more than 800,000 divorce cases are stored and managed by the system. Pekanbaru itself recorded total cases registered by the Secretariat of Religious Court of Pekanbaru in 2014 was 1,714 cases, this number increased by 7.62% from 2013 [3].

It can be concluded from the various sources which already mentioned earlier that year by year the number of divorce cases in Indonesia continues to increase and these will directly increase the amount of divorce decree data in various courts of religion in Indonesia.

These data actually are only used as a material for the recapitulation and publication for related parties. So far there has been no further research which utilizes those divorce decree data. With advances of information technology and methods in this day, it is possible to use these data as a basis to find and dig up new information or patterns which are useful; one of ways is to predict the result of a divorce case. It will be useful for the plaintiff or applicant who will be filing for divorce or *thalaq* divorce application.

Prediction results of this decision will certainly help prospective plaintiff or applicant, especially large numbers of potential plaintiff or applicant divorce does not yet have a fundamental knowledge about divorce case. Besides being able to help potential plaintiff or applicant, this prediction can also help lawyer to face his client's case.

One method that can carry out the extraction of the new information is Data Mining. Data mining can find relationships between data from an existing data set in order to obtain new information which is easily understandable and useful to the owner of the data [4].

This study will use a method of classification Naive Bayes classifier. Related studies used the method such as: Rodiansyah [5] used Naive Bayes classifier to classify twitter post of traffic jam in Bandung city with an accuracy rate of 93.65%. Kesumadewi [6] also applied Naive Bayes classifier to classify the nutritional status and the accuracy rate is 93.2%. Nugroho [7] used a Naive Bayes classifier to classify graduate student at the University of Dian Nuswantoro with an accuracy rate of 82.08%. In a study [8] says that Naive Bayes classifier method works very well compared with other classifier models. This study compared Naive Bayes, Decision Trees and Neural Network in classifying Training Web Pages.

Compared to other classification methods, Naive Bayes classifier has the best accuracy rate is 95.20%, also has faster computing time. Other research [9] using Naive Bayes for classification of four-wheeled vehicle with an accuracy of 86.243%. Widiastuti et al [10] used Naive Bayes-based Particle Swarm Optimization for the detection of cardiovascular disease with the highest accuracy of 92.86%.

Based on the problems described earlier, we conducted research on how Naive Bayes classifier can predict the result of a divorce case. With this method, it will classify a divorce case into the category is granted or rejected. The classification

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EVAPORATIVE COOLING UTILIZATION FOR ELECTRIC ENERGY SAVINGS ON SPLIT AIR-CONDITIONER

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***Abstract*—Air conditioner commonly uses a vapor-compression refrigeration system which require sizeable amount of power to operate with impact of refrigerant leak on environment to consider. This convenient, high performance system can fulfill relatively high cooling load with a small sized system. To minimalize the energy consumption of split air conditioner, evaporative cooling is added to the system. Azridjal Aziz (2015) added an evaporative cooling system in the condenser of split air conditioner, Chenguang Sheng and A.G. Agwu Nnanna (2012) use evaporative cooling pads to cool the room temperature directly, which results in lower energy consumption of air conditioner. Evaporative cooling is an air conditioning process which works by forming a direct contact between air and water vapor to enhance heat transfer and mass transfer between the two. Evaporative cooling in split air conditioner provides energy saving, lower temperature and humidity level of the air output corresponding with the international standards. According to the international standards, comfortable temperature are scaled between 22°C to 26°C with humidity of 40% to 70%. Evaporative cooling addition in split air conditioner use temperature variables of 20°C, 21°C, 22°C, 23°C, and 26°C. Evaporative cooled air conditioner with 22°C and 23°C temperature variables require lower energy consumption and the humidity level satisfy the international standard, while the 20°C and 21°C temperature variables also satisfy the humidity standard but require higher energy consumption. Evaporative cooled air conditioner with 26°C temperature variable require lower energy consumption but doesn't meet the humidity standard. Evaporative cooled air conditioner with 22°C and 23°C temperature variables yield relative humidity of 60,4% and 63,4% respectively and energy savings of 6,65% and 25,20% respectively. (Abstract)**

Keywords—evaporative cooling, energy savings, Air Conditioner, relative humidity, temperature

I. INTRODUCTION

Air conditioning is a process of air cooling to attain temperature, humidity and sanitation of an air flow corresponding with the comfort standard [1]. Air conditioning is no longer considered a luxury, but a necessity as a result of global warming caused by deforestation, multi-story buildings or greenhouse, industrial pollution and the depleted ozone layer [2]. Refrigeration (air conditioning) commonly uses vapor compression cycle, which require a large amount of electrical power to operate as well as the refrigerant affect on the environment [3]. This system has several advantages such as easy to operate, has high performance and can meet the needs of a relatively high cooling load with a small size system [4].

One of the solution to resolve its weakness is by using evaporative cooling. Chenguang Sheng, A.G. and Agwu Nanna 2012 has done a research using evaporative cooling pads to cools the room air directly [5]. Research is also carried out by Azridjal Aziz 2015 by adding the EC (evaporative cooling) on the condenser of Split Air Conditioner [6]. The addition of EC implies the electrical energy usage efficiency. Moreover it is more friendly towards the environment because no refrigerant is used. The refrigerant is replaced with atomized water with direct contact towards the air to reduce the negative impact on the environment [4]. Evaporative cooling occurs due to heat transfer and mass transfer between water vapor and air [4]. Evaporative cooling addition on the evaporator of split air conditioner saves energy consumption, lower the temperature and attain the humidity output of Split Air Conditioner that satisfy the international standards. Based on the international comfort standard, comfortable temperature is ranged between 22°C to 26°C with a humidity of 40% to 70% [7]-[8].

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A New Method Of Hill Cipher

The Rectangular Matrix As The Private Key

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***Abstract*—Hill Cipher is one of the symmetric key algorithms in cryptography. On the Hill Cipher, encryption and descriptions using the invertible matrix as a key. In this study, we introduce a new method on the Hill Cipher using a rectangular matrix as a key.**

***Keywords*—Hill Cipher, new method of Hill Cipher, the rectangular matrix, plaintext, ciphertext**

I. INTRODUCTION

Hill Cipher is one of the symmetric key algorithms in cryptography. On the Hill cipher, plaintext grouped into equal size blocks and defined over an alphabet of order M. The key matrix K in Hill Cipher must be invertible on $\bmod M$ and sized $n \times n$, where n is the size of the blocks in plaintext P. Furthermore, the plaintext P [1,2,3,4] is encrypted as $E_K(P) = KP \bmod M = C$ and described as $D_K(C) = K^{-1}C \bmod M = P$, with C is ciphertext.

In fact, not all of matrix K have an inverse on $\bmod M$. If K does not have an inverse on $\bmod M$, the ciphertext can not be described in plaintext, or description $D_K(C) = K^{-1}C \bmod M = P$ fails to do. This means that legitimate recipient can not read plaintext. Therefore, the matrix K [1,2,3] modified into an involutory matrix $K = K^{-1}$, so it an applicable description $P = D_K(C) = KC \bmod M$. Furthermore, the involutory matrix K can be expressed as $KK = I$.

We already know that the matrix K which does not have an inverse would be avoided in Hill Cipher. In fact, in these conditions, the plaintext will be more secure. In this study, we will use a matrix $\bar{K}$ that has no inverse on $\bmod M$. We choose the rectangular matrix $\bar{K}_{m \times n}$, where $m \neq n$. We also adopted an involutory matrix properties in [1,2,3]. We choose $T\bar{K} = I$, with $T_{n \times m}$, $\bar{K}_{m \times n}$, the identity matrix $I_{n \times n}$ and $m \neq n$ (T and $\bar{K}$ are rectangular matrices).

II. MAIN RESULT

A. Original Hill Cipher, Hill Cipher Using Involutory Matrix, and Hill Cipher Using Rectangular Matrix

We use plaintext P, ciphertext C, and key K. On the original Hill Cipher, we know that encryption

$$E_K(P_{n \times r}) = K_{n \times n} P_{n \times r} \bmod M = C_{n \times r}$$

and description

$$D_K(C_{n \times r}) = (K^{-1})_{n \times n} C_{n \times r} \bmod M = P_{n \times r}.$$

In [1,2,3], a matrix $K_{n \times n}$ is modified into an involutory matrix $K = K^{-1}$ or $KK = I$, where $I_{n \times n}$ is the identity matrix. We know that on [1,2,3], applied encryption as in original Hill Cipher and description

$$D_K(C_{n \times r}) = K_{n \times n} C_{n \times r} \bmod M = P_{n \times r}.$$

In this study, we adopt involutory matrix properties such as [1,2,3]. We also use matrix $\bar{K}$ (rectangular matrix) that applies $T_{n \times m} \bar{K}_{m \times n} = I_{n \times n}$, where $m \neq n$. If we have $\bar{K}_{m \times n} P_{n \times r} \bmod M = C_{m \times r}$ then obtained

$$T_{n \times m} \bar{K}_{m \times n} P_{n \times r} \bmod M = T_{n \times m} C_{m \times r}$$
$$I_{n \times n} P_{n \times r} \bmod M = T_{n \times m} C_{m \times r} \bmod M$$
$$P_{n \times r} = T_{n \times m} C_{m \times r} \bmod M$$

Based on these facts, we get encryption

$$E_{\bar{K}}(P_{n \times r}) = \bar{K}_{m \times n} P_{n \times r} \bmod M = C_{m \times r}$$

and description

$$D_{\bar{K}}(C_{m \times r}) = T_{n \times m} C_{m \times r} \bmod M = P_{n \times r}$$

where $T_{n \times m} \bar{K}_{m \times n} = I_{n \times n}$. Furthermore, this algorithm is called the Hill Cipher using rectangular matrix.

B. Security Analysis

One of the strengths Hill Cipher using a rectangular matrix is the matrix size of ciphertext and plaintext is not equal. So, the plaintext is more difficult to describe because there is no one-to-one correspondence between plaintext and ciphertext.

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Modeling of Analytic Hierarchy Process and Simple Additive Weighting for Selection of Regional Development Renewable Energy Center

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***Abstract*— Based on the law of energy, the government is required to develop potential alternative energy made of palm to overcome the crisis of electricity like in Riau. Consider that Indonesia has a large area that planted by palm and produce palm in high number, Riau is predicted to be able to develop the renewable energy center. Related to this, government policy is needed in determining the in the area based on the potential and predetermined criteria. Simple Additive weighting is a method of decision making based on a weighted sum capable of providing renewable energy-related decisions. The decision factor is not the decision of ranking the results based on the main criteria such as plantation area and production results, but four other factors have the potential to influence the outcome. Also, the weighting using Analytical Hierarchy Process method is more efficient than the ordinary preference weighting because Eigen value does not affect the decision result significantly.**

Keywords: Analytic Hierarchy process, Eigen, Renewable Energy, Simple Additive Weighting

I. INTRODUCTION (*HEADING 1*)

Energy development in Indonesia has changed from the exporter into the importer country. Both regional and center government have established policies to save the energy, but many parties perceive it does not run maximally. Energy crisis which happened in most of the corner regions in Indonesia gives negative impact to the growth of economy sector. Every year energy crisis always occurs in areas which produce main energy in this country, including Kalimantan and Riau.

Blueprint of national energy management 2006-2025 states that the biggest problems related to energy in Indonesia was the Indonesian Budget (APBN) still depends on oil and gas and subsidized fuel oil (BBM), energy industry doesn't run optimally, infrastructure of energy is still limited, there is no achieving the economic price and inefficient use of energy [10]. These problems cause the productivity of energy and economy in Indonesia getting weaker, , especially the one which related to the problem in depending on fuel oil (BBM) where fuel fossil energy will decrease everyday [15].

Apart from the points above, based on the Law No. 30/2007 concerning the energy chapter 20 verse 4 stated that the provision and utilization of new and renewable energy should be increased by the central government and local governments according to their authorities. One of the renewable energy that is defined in the Law is biomass; the main ingredient of biomass is palm [8]. By using palm and palm waste as the main ingredients and using conversion technology of energy, the energy can be used to generate the electrical energy such as a fuel source of Steam Power Palnt (Pembangkit Listrik Tenaga Uap [PLTU]). The electrical energy produced by the energy conversion is highly dependent on the waste generated by the palm oil processing center [8].

Riau Province is a province with an area of 8.91 million Ha, it has the potential to produce the biggest palm oil in Indonesia because it has a plantation area of 2.26 million Ha with an average production of 6.93 million tons per year in the various districts [15]. Each year the productivity of Palm oil in Riau province has increased both in production and plantation area. It became an image of the realization of alternative energy made of palm oil for the foreseeable future with projections of waste produced as a substitute for fossil energy. From sources released by the Central Statistics Agency (Badan Pusat Statistik [BPS]) there is a decrease in the value of some area, it is due to the changes or replanting of palm oil which has reached the age limit.

The relation between energy alternative to palm oil production cannot be separated with the condition of the sources which produce raw materials. The government is expected to coordinate and prioritize the policies related to equal distribution of energy in a region [14] . One of the real manifestation of the government's role is to make the selection and scoring of the renewable energy development center in the form of decision-making.

In the 1980s Thomas Saaty introduced a method with a pattern that is often used in making decisions based on the theory that reflects the way the people think. In the development of this method, it can be used as an alternative in

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Inverse of Tridiagonal Toeplitz Matrix By Adjoint Method

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***Abstract*— Inverse of a matrix is important in mathematics, specially in algebra. Inverse of matrix applicate in many sectors, either in mathematics or another sector. There are many methods to determine the inverse of a matrix, one of them is adjoint method. The adjoint method is a simple method to determine the inverse of a matrix. This paper want to determine the general formula to find the inverse of a tridiagonal toeplitz matrix by adjoint method. There are three steps to determine inverse of a tridiagonal toeplitz matrix. The first one, find general formula of determinant of tridiagonal toeplitz matrix. The second one, find general formula of cofactor matrix of tridiagonal toeplitz matrix. And the last one, find the general formula of inverse of tridiagonal toeplitz matrix.**

Keywords*— *adjoint, determinant, invers of matrix, cofactor matrix, tridiagonal toeplitz matrix

I. Introduction

Howard Anton dan Chris Rorres in [1] define that matrix is square array of numbers. One of kind of matrix is toeplitz matrix. Robert in [2] define toeplitz matrix as a symmetric and circulant matrix, which is every element in the main diagonal are same and every element in corresponding subdiagonal with its main diagonal are also same. General formula of toeplitz matrix is followed.

$$T_n = (t_{ij})\begin{bmatrix} t_0 & t_{-1} & t_{-2} & \cdots & t_{-(n-2)} & t_{-(n-1)} \\ t_1 & t_0 & t_{-1} & \cdots & t_{-(n-3)} & t_{-(n-2)} \\ t_2 & t_1 & t_0 & \cdots & t_{-(n-4)} & t_{-(n-3)} \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ t_{(n-2)} & t_{(n-3)} & t_{(n-4)} & \cdots & t_0 & t_{-1} \\ t_{(n-1)} & t_{(n-2)} & t_{(n-3)} & \cdots & t_1 & t_0 \end{bmatrix} \quad (1)$$

Which is t_{ij} is element in the i-th row and j-th column.

One of kind of toeplitz matrix is tridiagonal toeplitz matrix. Salkuyeh [8] define this matrix as a matrix with form :

$$A = \begin{bmatrix} b & c & 0 & 0 & 0 & 0 \\ a & b & c & 0 & 0 & 0 \\ 0 & a & b & c & 0 & 0 \\ 0 & 0 & \ddots & \ddots & \ddots & 0 \\ 0 & 0 & 0 & a & b & c \\ 0 & 0 & 0 & 0 & a & b \end{bmatrix} \quad (2)$$

with $a, c \neq 0 \in \mathbb{R}$.

A matrix is invertible if determinant of the matrix is not same with 0. There are many methods to determine inverse of a matrix, they are substitution, partition of matrix, adjoint matrix, Gauss Elimination, Gauss-Jordan Elimination, multiply elementary inverse matrix, and matrix decomposition LU. If the order of a matrix bigger then we are more difficult to determine its inverse, so we need a better formula to determine inverse of a special matrix.

Bakti Siregar et. al. [10] have found a general formula to determine inverse of toeplitz matrix with special form as followed.

$$T_n = \begin{bmatrix} 0 & x & \cdots & x \\ x & 0 & \cdots & x \\ \vdots & \vdots & \ddots & \vdots \\ x & x & \cdots & 0 \end{bmatrix} \forall\, x \in \mathbb{R} \quad (3)$$

The result of their research are followed :

1. Formula to calculate determinant of a toeplitz matrix order n in (3) is
$$\det(T_n) = (-1)^n(n-1)x^n$$
2. Formula to determine cofactor matrix $[K_{ij}T_n]$ order n in (3) is
$$K_{ij}T_n = \begin{cases} \det(T_n) & ;\text{if } i = j \\ (-1)^{n+1}x^{n-1} & ;\text{if } i \neq j \end{cases}$$
3. Formula to determine inverse of toeplitz matrix order n in (3) is
$$T_n^{-1} = t_{ij} = \begin{cases} \dfrac{-n-2}{(n-1)x} & ;\text{if } i = j \\ \dfrac{1}{(n-1)x} & ;\text{if } i \neq j \end{cases}$$

From this result, we can see that there is a formula to calculate determinant, to determine cofactor matrix and inverse of a toeplitz matrix with form in (3). So, we can easier to find determinant, cofactor matrix, and inverse of the matrix, that is only input value of n and x of the matrix to formula of determinant, cofactor matrix, and inverse of the matrix which have found.

Motivated by result of Bakti Siregar's research in [10], we interested to find inverse of another matrix, that is tridiagonal toeplitz matrix. So, in this paper, we determine the general

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formula to determine determinant, cofactor matrix, and inverse of tridiagonal toeplitz matrix in (2).

II. TRIDIAGONAL TOEPLITZ MATRIX

Definition 1 [2] A toeplitz matrix is an $n \times n$ matrix $T_n = [t_{kj}; k, j = 0,1, \dots, n-1]]$ where $t_{kj} = t_{k-j}$, a matrix of the form

$$T_n = \begin{bmatrix} t_0 & t_{-1} & t_{-2} & \cdots & t_{-(n-1)} \\ t_1 & t_0 & t_{-1} & \cdots & t_{-(n-2)} \\ t_2 & t_1 & t_0 & \cdots & t_{-(n-3)} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ t_{(n-1)} & t_{(n-1)} & \cdots & t_1 & t_0 \end{bmatrix}$$

Based on Definition 1, then are different kinds of toeplitz matrix, within one is toeplitz tridiagonal matrix.

Definition 2 [8] A matrix is an $n \times n$ said matrix tridiagonal toeplitz matrix with orde n if a matrix of the form

$$A = \begin{bmatrix} b & c & 0 & 0 & 0 & 0 \\ a & b & c & 0 & 0 & 0 \\ 0 & a & b & c & 0 & 0 \\ 0 & 0 & \ddots & \ddots & \ddots & 0 \\ 0 & 0 & 0 & a & b & c \\ 0 & 0 & 0 & 0 & a & b \end{bmatrix} \quad \text{dengan } a, c \neq 0 \in \mathbb{R}.$$

There are several methods to determine the determinant of a square matrix, namely Sarrus Method, Minor and Cofactor Method, Chio Method, Gaussian Elimination Method and Matrix Decomposition Method. The author simply using minor and cofactor in finding the determinant of a matrix.

A matrix A has an inverse or invertible can be seen from the determinant of the matrix A. If $\det(A) \neq 0$ means that the matrix A has an inverse. Determining the inverse of a matrix can use adjoin method. Adjoint method obtained from transpose of matrix cofactors and denoted by $adj\ (A)$. So, inverse of matrix A is:

$$A^{-1} = \frac{1}{\det(A)} adj(A)$$

Toeplitz matrix covered by Bakti Siregar, et al in [10] was T_n Toeplitz matrix as (3). The matrix will be determined on the determinants, matrix cofactors, and its inverse, with the following steps:

a. Determinant of Toeplitz Matrix

To obtain the value of the determinant formula toeplitz matrix is done by examining the pattern matrix toeplitz determinants $T_n$the order of 2×2 to 7×7 by using elementary row operations. The operation can be seen in the following process:

1. Suppose toeplitz matrix of order 2×2 is $T_2 = \begin{bmatrix} 0 & x \\ x & 0 \end{bmatrix}$ where $\forall x \in \mathbb{R}$ thus obtained

$$|T_2| = \begin{vmatrix} 0 & x \\ x & 0 \end{vmatrix} (B_1 \leftrightarrow B_2) - \begin{vmatrix} 0 & x \\ x & 0 \end{vmatrix} = -x^2 \text{ then } |T_2| = -x^2$$

2. Suppose toeplitz matrix of order 3×3 is $T_3 = \begin{bmatrix} 0 & x & x \\ x & 0 & x \\ x & x & 0 \end{bmatrix}$ where $\forall x \in \mathbb{R}$ thus obtained

$$|T_3| = \begin{vmatrix} 0 & x & x \\ x & 0 & x \\ x & x & 0 \end{vmatrix} (B_1 \leftrightarrow B_3) - \begin{vmatrix} x & x & 0 \\ x & 0 & x \\ 0 & x & x \end{vmatrix} (B_1 - B_2)$$
$$- \begin{vmatrix} x & x & x \\ 0 & x & -x \\ 0 & x & x \end{vmatrix} (B_2 - B_3) = - \begin{vmatrix} x & x & 0 \\ 0 & x & x \\ 0 & 0 & -2x \end{vmatrix} = 2x^3,$$

The process for obtaining the determinant of the matrix toeplitz T_4, T_5, T_6 and T_7 can be searched in the same way in order to get the results in tabular form as shown below

TABLE 1. DETERMINANT TOEPLITZ MATRIX T_n

No	Toeplitz Matrix T_n	Determinant
1	T_2	$-x^2$
2	T_3	$2x^3$
3	T_4	$-3x^4$
4	T_5	$4x^5$
5	T_6	$-5x^6$
6	T_7	$6x^7$

From Table 1 can be obtained that the pattern of the value of the determinant of the matrix toeplitz T_n seen in Theorem 1.

Theorem 1 [10] Suppose T_n a toeplitz matrix of order $n \geq 2$ in (3) where the value of the determinant of the matrix $\forall x \in \mathbb{R}$ T_n is

$$|T_n| = (-1)^{n+1}(n-1)x^n$$

b. Matriks kofaktor dari matriks toeplitz

To determine the inverse matrix T_n, necessary cofactors of the matrix T_n. Formula cofactors $T_n$matrix can be seen in Theorem 2.

Theorem 2 [10] Suppose T_n a toeplitz matrix of order $n \geq 2$ in (3) where $\forall x \in \mathbb{R}$ the cofaktors matrix toeplitz T_n is

$$K_{ij}T_n = \begin{cases} |T_{n-1}|, & untuk\ i = j \\ (-1)^{n+1}x^{n-1}, & untuk\ i \neq j \end{cases}$$

where $K_{ij}T_n$ kofaktors which is the-i th row and j-th column.

Theorem 2 show that cofaktors matrix T_n secara umum, so in Theorem 3 will be show inverse matrix T_n obtained with use method adjoint matrix T_n.

Theorem 3 [10] Suppose T_n a toeplitz matrix of order $n \geq 2$ in (3) where $\forall x \in \mathbb{R}$ and $|T_n| \neq 0$ then inverse toeplitz matrix T_n is

$$T_n^{-1} = t_{ij} = \begin{cases} \dfrac{-(n-2)}{(n-1)x}, & untuk\ i = j \\ \dfrac{1}{(n-1)x}, & untuk\ i \neq j \end{cases}$$

t_{ij} are entries which is the-i th row and j-th column

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III. MAIN RESULT

To obtain the value of the determinant formula tridiagonal toeplitz matrix is done by examining the pattern matrix tridiagonal Toeplitz determinants T_n the order of 3x3 to 20x20 and then we'll make a common form of the determinant of the tridiagonal Toeplitz matrix. Seen in theorem 4 below:

Theorem 4. Given A_n a toeplitz tridiagonal matrix of order $n \geq 3$ in (2) where $a, b, c \in \mathbb{R}$ then the value of the determinant of matrix A_n is:

$$|A_n| = b^n - (n-1)ab^{n-2}c + \sum_{i=1}^{n-3} ia^2b^{n-4}c^2 - \left(\sum_{i=1}^{1} i + \sum_{i=1}^{2} i + \cdots + \sum_{i=1}^{n-5} i\right)a^3b^{n-6}c^3$$
$$+\left[\frac{(n-7)}{1!}\sum_{i=1}^{1} i + \frac{(n-8)}{1!}\sum_{i=1}^{2} i + \frac{(n-9)}{1!}\sum_{i=1}^{3} i + \cdots + 1\sum_{i=1}^{n-7} i\right]a^4b^{n-8}c^4$$
$$-\left[\frac{(n-9)(n-8)}{2!}\sum_{i=1}^{1} i + \frac{(n-10)(n-9)}{2!}\sum_{i=1}^{1} i + \cdots + 1\sum_{i=1}^{n-9} i\right]a^5b^{n-10}c^5$$
$$+\left[\frac{(n-11)(n-10)(n-9)}{3!}\sum_{i=1}^{1} i + \frac{(n-12)(n-11)(n-10)}{3!}\sum_{i=1}^{1} i + \cdots + 1\sum_{i=1}^{n-11} i\right]$$
$$a^6b^{n-12}c^6$$
$$-\left[\frac{(n-13)(n-12)(n-11)(n-10)}{4!}\sum_{i=1}^{1} i + \frac{(n-14)(n-13)(n-12)(n-11)}{4!}\sum_{i=1}^{1} i + \cdots + 1\sum_{i=1}^{n-13} i\right]^7 b^{n-14}c^7 + \ldots \quad (4)$$

Proof of the theorem by using mathematical induction

Proof:

Prove of the theorem by using mathematical induction

1. for $n = 3$ then apply

$$|A| = b^3 - 2abc + 0$$
$$= b^3 - 2abc$$

,true.

2. Assume true for $n = k$ true, ie

$$|A_k| = b^k - (k-1)ab^{k-2}c + \sum_{i=1}^{k-3} ia^2b^{k-4}c^2 - \left(\sum_{i=1}^{1} i + \sum_{i=1}^{2} i + \cdots + \sum_{i=1}^{k-5} i\right)a^3b^{k-6}c^3$$
$$+\left[\frac{(k-7)}{1!}\sum_{i=1}^{1} i + \frac{(k-8)}{1!}\sum_{i=1}^{2} i + \frac{(k-9)}{1!}\sum_{i=1}^{3} i + \cdots + 1\sum_{i=1}^{k-7} i\right]a^4b^{k-8}c^4$$
$$-\left[\frac{(k-9)(k-8)}{2!}\sum_{i=1}^{1} i + \frac{(k-10)(k-9)}{2!}\sum_{i=1}^{1} i + \cdots + 1\sum_{i=1}^{k-9} i\right]a^5b^{k-10}c^5$$
$$+\left[\frac{(k-11)(k-10)(k-9)}{3!}\sum_{i=1}^{1} i + \frac{(k-12)(k-11)(k-10)}{3!}\sum_{i=1}^{1} i + \cdots + 1\sum_{i=1}^{k-11} i\right]$$
$$a^6b^{k-12}c^6$$
$$-\left[\frac{(k-13)(k-12)(k-11)(k-10)}{4!}\sum_{i=1}^{1} i + \frac{(k-14)(k-13)(k-12)(k-11)}{4!}\sum_{i=1}^{1} i + \cdots + 1\sum_{i=1}^{k-13} i\right]$$
$$a^7b^{k-14}c^7 + \cdots$$

3. Will be shown for $n = k + 1$ is also true,

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$$|A_{k+1}| = b|A_k| - ac|A_{k-1}|$$

$$= b^{k+1} - (k-1)ab^{k-1}c + \sum_{i=1}^{k-3} i.\, a^2b^{k-3}c^2 - \left(\sum_{i=1}^{1} i + \sum_{i=1}^{2} i + \cdots + \sum_{i=1}^{k-5} i\right)a^3b^{k-5}c^3$$

$$+\left[\frac{(k-7)}{1!}\sum_{i=1}^{i} i + \frac{(k-8)}{1!}\sum_{i=1}^{2} i + \frac{(k-9)}{1!}\sum_{i=1}^{3} i + \cdots + 1\cdot\sum_{i=1}^{k-7} i\right]a^4b^{k-7}c^4$$

$$-\left[\frac{(k-9)(k-8)}{2!}\sum_{i=1}^{1} i + \frac{(k-10)(k-9)}{2!}\sum_{i=1}^{2} i + \cdots + 1\cdot\sum_{i=1}^{k-9} i\right]a^5b^{k-9}c^5$$

$$+\left[\frac{(k-11)(k-10)(k-9)}{3!}\sum_{i=1}^{1} i + \frac{(k-12)(k-11)(k-10)}{3!}\sum_{i=1}^{2} i + \cdots + 1.\sum_{i=1}^{k-11} i\right]a^6b^{k-11}c^6$$

$$+\cdots+\left[\frac{(k-13)(k-12)(k-11)(k-10)}{4!}\sum_{i=1}^{1} i + \cdots + \frac{(k-14)(k-13)(k-12)(k-11)}{4!}\sum_{i=1}^{2} i + \cdots + 1.\sum_{i=1}^{k-13} i\right]a^7b^{k-13}c^8$$

$$+\ldots - ac\left\{b^{k-1} - (k-2)\,ab^{k-3}c + \sum_{i=1}^{k-4} i.a^2b^{k-5}c^2 - \left(\sum_{i=1}^{1} i + \sum_{i=1}^{2} i + \cdots + \sum_{i=1}^{k-6} i\right)a^3b^{k-7}c^3\right.$$

$$+\left[\frac{k-8}{1!}\sum_{i=1}^{1} i + \frac{k-9}{1!}\sum_{i=1}^{2} i + (k-10)\sum_{i=1}^{3} i + \cdots \sum_{i=1}^{k-8} i\right]a^4b^{k-9}c^4$$

$$-\left[\frac{(k-10)(k-9)}{2!}\sum_{i=1}^{1} i + \frac{(k-11)(k-10)}{2!}\sum_{i=1}^{2} i \cdots + 1.\sum_{i=1}^{k-10} i\right]a^5b^{k-11}c^5$$

$$\left.+\left[\frac{(k-12)(k-11)(k-10)}{3!}\sum_{i=1}^{1} i + \frac{(k-13)(k-12)(k-11)}{3!}\sum_{i=1}^{2} i + \cdots + 1.\sum_{i=1}^{k-12} i\right]a^7b^{k-15}c^7 + \cdots\right\}$$

It means we get

$$= b^{k+1} - kab^{k-1}c + \sum_{i=1}^{k-2} i.a^2b^{k-3}c^2 - \left(\sum_{i=1}^{1} i + \sum_{i=1}^{2} i + \cdots + \sum_{i=1}^{k-4} i\right)a^3b^{k-5}c^3$$

$$+\left[(k-6)\sum_{i=1}^{1} i + (k-7)\sum_{i=1}^{2} i + (k-8)\sum_{i=1}^{3} i + \cdots + 1.\sum_{i=1}^{k-6} i\right]a^4b^{k-7}c^4$$

$$-\left[\frac{(k-8)(k-7)}{2!}\sum_{i=1}^{1} i + \frac{(k-9)(k-8)}{2!}\sum_{i=1}^{2} i + \frac{(k-10)(k-9)}{2!}\sum_{i=1}^{3} i + \cdots + 1.\sum_{i=1}^{k-8} i\right]a^5b^{k-9}c^5$$

$$+\left[\frac{(k-10)(k-9)(k-8)}{3!}\sum_{i=1}^{1} i + \frac{(k-11)(k-10)(k-9)}{3!}\sum_{i=1}^{2} i + \cdots 1.\sum_{i=1}^{k-10} i\right]a^6b^{k-11}c^6$$

$$-\left[\frac{(k-12)(k-11)(k-10)(k-9)}{4!}\sum_{i=1}^{1} i + \frac{(k-13)(k-12)(k-11)(k-10)}{4!}\sum_{i=1}^{2} i + \cdots + \sum_{i=1}^{k-12} i\right]a^8b^{k-13}c^8 + \cdots$$

Proof ends.

Specifies known cofactor matrix using the equation $C_{ij} = (-1)^{i+j}M_{ij}$. Then get the matrix of cofactors for tridiagonal toeplitz matrix. So we can formulate the general form of the cofactor matrix to tridiagonal toeplitz matrix of order $n \times n$. The following general formulation of cofactor matrix of toeplitz tridiagonal matrix of order $n \times n$ in the theorem 5.

Theorem 5 Given A_n a toeplitz tridiagonal matrix of order $n \geq 3$ in (2) where $a, b, c \in \mathbb{R}$ then cofactor matrix from A_n is:

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$$C_n = \begin{bmatrix} (-1)^2|A_{n-1}| & (-1)^3 a|A_{n-2}| & (-1)^4 a|A_{n-3}| & \cdots & (-1)^n a^{n-2}|A_1| & (-1)^{n+1} a^{n-1} \\ (-1)^3 c|A_{n-2}| & (-1)^4 |A_1||A_{n-2}| & (-1)^5 a|A_1||A_{n-3}| & \cdots & (-1)^{n+1} a^{n-3}|A_1||A_1| & (-1)^{n+2} a^{n-2}|A_1| \\ (-1)^4 c^2|A_{n-3}| & (-1)^5 c|A_1||A_{n-3}| & (-1)^6 |A_2||A_{n-3}| & \cdots & (-1)^{n+2} a^{n-4}|A_1||A_2| & (-1)^{n+3} a^{n-3}|A_2| \\ (-1)^5 c^3|A_{n-4}| & (-1)^6 c^2|A_2||A_{n-4}| & (-1)^7 c|A_2||A_{n-4}| & \cdots & (-1)^{n+3} a^{n-5}|A_1||A_3| & (-1)^{n+4} a^{n-4}|A_3| \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ (-1)^n c^{n-2}|A_1| & (-1)^{n+1} c^{n-3}|A_1||A_1| & (-1)^{n+2} c^{n-4}|A_1||A_2| & \cdots & (-1)^{n+n-2}|A_{n-2}||A_1| & (-1)^{n+n-2} a|A_{n-2}| \\ (-1)^{n+1} c^{n-1} & (-1)^{n+2} c^{n-2}|A_1| & (-1)^{n+3} c^{n-3}|A_2| & \cdots & (-1)^{n+n-1} c|A_{n-2}| & (-1)^{2n} c|A_{n-1}| \end{bmatrix}$$

Proof:

Consider the following matrix

$$A_n = \begin{bmatrix} b & c & 0 & 0 & \cdots & 0 & 0 & 0 \\ a & b & c & 0 & \cdots & 0 & 0 & 0 \\ 0 & a & b & c & \cdots & 0 & 0 & 0 \\ 0 & 0 & a & b & \cdots & 0 & 0 & 0 \\ \vdots & & & & & & & \\ 0 & 0 & 0 & 0 & \cdots & a & b & c \\ 0 & 0 & 0 & 0 & \cdots & 0 & a & b \end{bmatrix} \quad where \quad a,b,c \in R$$

Furthermore, we will verify every entry of the matrix cofactor. Starting from the entry cofactor matrix first row and the first column to the first row to the n-column . Furthermore, the second row and the first column to the second row and n - column. Onwards to do the same thing to the n- row and n - column . The process is given as follows:

a. Entries first line of the matrix of cofactors as follows:

$$C_{11} = (-1)^2 \begin{vmatrix} b & c & 0 & \cdots & 0 & 0 & 0 \\ a & b & c & \cdots & 0 & 0 & 0 \\ 0 & a & b & \cdots & & & \\ \vdots & & & & & & \\ 0 & 0 & 0 & \cdots & a & b & c \\ 0 & 0 & 0 & \cdots & 0 & a & b \end{vmatrix}_{n-1} = (-1)^2|A_{n-1}|$$

$$C_{12} = (-1)^3 \begin{vmatrix} a & c & 0 & \cdots & 0 & 0 & 0 \\ 0 & b & c & \cdots & 0 & 0 & 0 \\ 0 & a & b & \cdots & 0 & 0 & 0 \\ \vdots & & & & & & \\ 0 & 0 & 0 & \cdots & a & b & c \\ 0 & 0 & 0 & \cdots & 0 & a & b \end{vmatrix}_{n-1} = (-1)^3 a|A_{n-2}|$$

The same thing is done up C_{1n}, so that we can shape public for the first line entry matrix cofactors, namely:

$$C_{1n} = (-1)^{n+1} \begin{vmatrix} a & b & c & 0 & \cdots & 0 & 0 \\ 0 & a & b & c & \cdots & 0 & 0 \\ 0 & 0 & a & b & \cdots & 0 & 0 \\ \vdots & & & & & & \\ 0 & 0 & 0 & 0 & \cdots & a & b \\ 0 & 0 & 0 & 0 & \cdots & 0 & b \end{vmatrix}_{n-1} = (-1)^{n+1} a^{n-1}$$

b. Entries second line of the matrix of cofactors as follows

$$C_{21} = (-1)^3 \begin{vmatrix} c & 0 & 0 & \cdots & 0 & 0 & 0 \\ a & b & c & \cdots & 0 & 0 & 0 \\ 0 & a & b & \cdots & 0 & 0 & 0 \\ \vdots & & & & & & \\ 0 & 0 & 0 & \cdots & a & b & c \\ 0 & 0 & 0 & \cdots & 0 & a & b \end{vmatrix}_{n-1} = (-1)^3 c|A_{n-2}|$$

$$C_{22} = (-1)^4 \begin{vmatrix} b & 0 & 0 & \cdots & 0 & 0 & 0 \\ a & c & 0 & \cdots & 0 & 0 & 0 \\ 0 & b & c & \cdots & 0 & 0 & 0 \\ 0 & a & b & \cdots & 0 & 0 & 0 \\ \vdots & & & & & & \\ 0 & 0 & 0 & \cdots & a & b & c \\ 0 & 0 & 0 & \cdots & 0 & a & b \end{vmatrix}_{n-1} = (-1)^4 |A_{n-2}|.b = (-1)|A_{n-2}||A$$

The same thing is done up, so that we can shape common to the second line entry matrix cofactors, namely:

$$C_{2n} = (-1)^{n+2} \begin{vmatrix} b & c & 0 & 0 & \cdots & 0 & 0 \\ 0 & a & b & c & \cdots & 0 & 0 \\ 0 & 0 & a & b & \cdots & 0 & 0 \\ \vdots & & & & & & \\ 0 & 0 & 0 & 0 & \cdots & a & b \\ 0 & 0 & 0 & 0 & \cdots & 0 & a \end{vmatrix} = (-1)^{n+2} b\, a^{n-2} =$$

c. The third line entry cofactor matrix as follows

$$C_{31} = (-1)^4 \begin{vmatrix} c & 0 & 0 & \cdots & 0 & 0 & 0 \\ b & c & 0 & \cdots & 0 & 0 & 0 \\ a & a & b & \cdots & 0 & 0 & 0 \\ \vdots & & & & & & \\ 0 & 0 & 0 & \cdots & a & b & c \\ 0 & 0 & 0 & \cdots & 0 & a & b \end{vmatrix}_{n-1} = (-1)^4 c|A_{n-3}|$$

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$$C_{32} = (-1)^5 \begin{vmatrix} b & 0 & 0 & \cdots & 0 & 0 & 0 \\ a & c & 0 & \cdots & 0 & 0 & 0 \\ 0 & a & b & \cdots & 0 & 0 & 0 \\ \vdots & & & & & & \\ 0 & 0 & 0 & \cdots & a & b & c \\ 0 & 0 & 0 & \cdots & 0 & a & b \end{vmatrix}_{n-1}$$

$$= (-1)^5 \, b \, . \, c \, |A_{n-3}| = (-1)^5 \, c \, |A_1| \, |A_{n-3}|$$

The same thing is done up, so that we can shape common to the second line entry matrix cofactors, namely:

$$C_{3n} = (-1)^{n+3} \begin{vmatrix} b & c & 0 & 0 & \cdots & 0 & 0 \\ a & b & c & 0 & \cdots & 0 & 0 \\ 0 & 0 & a & b & \cdots & 0 & 0 \\ \vdots & & & & & & \\ 0 & 0 & 0 & 0 & \cdots & a & b \\ 0 & 0 & 0 & 0 & \cdots & 0 & a \end{vmatrix}_{n-1} = (-1)^{n+3} \, a^{n-3} \, |A_2|$$

Entries row 4,5,6 and so on is done in the same way, so that the obtained entry for the n-th row as follows:

$$C_{n1} = (-1)^{n+1} \begin{vmatrix} c & 0 & 0 & \cdots & 0 & 0 & 0 \\ b & c & 0 & \cdots & 0 & 0 & 0 \\ a & b & c & \cdots & 0 & 0 & 0 \\ 0 & a & b & \cdots & 0 & 0 & 0 \\ \vdots & & & & & & \\ 0 & 0 & 0 & \cdots & a & b & c \end{vmatrix}_{n-1} = (-1)^{n+1} \, c^{n-1}$$

From the above calculation, obtained:

$$C_n = \begin{bmatrix} (-1)^2 |A_{n-1}| & (-1)^3 a |A_{n-2}| & (-1)^4 a |A_{n-3}| & \cdots & (-1)^n a^{n-2} |A_1| & (-1)^{n+1} a^{n-1} \\ (-1)^3 c |A_{n-2}| & (-1)^4 |A_1| |A_{n-2}| & (-1)^5 a |A_1| |A_{n-3}| & \cdots & (-1)^{n+1} a^{n-3} |A_1| |A_1| & (-1)^{n+2} a^{n-2} |A_1| \\ (-1)^4 c^2 |A_{n-3}| & (-1)^5 c |A_1| |A_{n-3}| & (-1)^6 |A_2| |A_{n-3}| & \cdots & (-1)^{n+2} a^{n-4} |A_1| |A_2| & (-1)^{n+3} a^{n-3} |A_2| \\ (-1)^5 c^3 |A_{n-4}| & (-1)^6 c^2 |A_2| |A_{n-4}| & (-1)^7 c |A_2| |A_{n-4}| & \cdots & (-1)^{n+3} a^{n-5} |A_1| |A_3| & (-1)^{n+4} a^{n-4} |A_3| \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ (-1)^n c^{n-2} |A_1| & (-1)^{n+1} c^{n-3} |A_1| |A_1| & (-1)^{n+2} c^{n-4} |A_1| |A_2| & \cdots & (-1)^{n+n-2} |A_{n-2}| |A_1| & (-1)^{n+n-2} a |A_{n-2}| \\ (-1)^{n+1} c^{n-1} & (-1)^{n+2} c^{n-2} |A_1| & (-1)^{n+3} c^{n-3} |A_2| & \cdots & (-1)^{n+n-1} c |A_{n-2}| & (-1)^{2n} c |A_{n-1}| \end{bmatrix}$$

Proof complete.

Of the matrix of cofactors above we will determine the adjoint of the matrix of cofactors. Adjoint determine the matrix of cofactors in a way transposed the matrix cofactors, ie the change rows into columns and change the column into row, as follows:

$$C_{n2} = (-1)^{n+2} \begin{vmatrix} b & 0 & 0 & \cdots & 0 & 0 & 0 \\ a & c & 0 & \cdots & 0 & 0 & 0 \\ 0 & b & c & \cdots & 0 & 0 & 0 \\ 0 & a & b & \cdots & 0 & 0 & 0 \\ \vdots & & & & & & \\ 0 & 0 & 0 & \cdots & a & b & c \end{vmatrix}_{n-1}$$

$$= (-1)^{n+2} \, b \, . \, c^{n-1} = (-1)^{n+2} \, c^{n-2} \, |A_1|$$

The same thing is done up, so that we can shape common to the second line entry matrix cofactors, namely:

$$C_{nn} = (-1)^{2n} \begin{vmatrix} b & c & 0 & 0 & \cdots & 0 & 0 \\ a & b & c & 0 & \cdots & 0 & 0 \\ 0 & a & b & c & \cdots & 0 & 0 \\ 0 & 0 & a & b & \cdots & 0 & 0 \\ \vdots & & & & & & \\ 0 & 0 & 0 & 0 & \cdots & a & b \end{vmatrix}_{n-1} = (-1)^{2n} \, |A_{n-1}|$$

$$Adj(A_n)=\begin{bmatrix}
(-1)^2|A_{n-1}| & (-1)^3 c|A_{n-2}| & (-1)^4 c^2|A_{n-3}| & (-1)^5 c^3|A_{n-4}| & \cdots & (-1)^n c^{n-2}|A_2| & (-1)^{n+1}c^{n-1}\\
(-1)^3 a|A_{n-2}| & (-1)^4|A_1||A_{n-2}| & (-1)^5 c|A_1||A_{n-3}| & (-1)^6 c^2|A_2||A_{n-4}| & \cdots & (-1)^{n+1}c^{n-3}|A_1||A_4| & (-1)^{n+2}c^{n-2}|A_1|\\
(-1)^4 a|A_{n-3}| & (-1)^5 a|A_2||A_{n-3}| & (-1)^6|A_2||A_{n-3}| & (-1)^7 c|A_2||A_{n-4}| & \cdots & (-1)^{n+2}c^{n-4}|A_1||A_3| & (-1)^{n+3}c^{n-3}|A_2|\\
\vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots\\
(-1)^n a^{n-2}|A_1| & (-1)^{n+1}a^{n-3}|A_1||A_1| & (-1)^{n+2}a^{n-4}|A_2||A_2| & (-1)^{n+3}a^{n-5}|A_1||A_3| & \cdots & (-1)^{n+n-2}|A_{n-2}||A_1| & (-1)^{n+n-1}c|A_{n-2}|\\
(-1)^{n+1}a^{n-1} & (-1)^{n+2}a^{n-2}|A_1| & (-1)^{n+3}a^{n-3}|A_2| & (-1)^{n+4}a^{n-4}|A_2| & \cdots & (-1)^{n+n-2}a|A_{n-2}| & (-1)^{2n}c|A_{n-1}|
\end{bmatrix} \quad (5)$$

The third general formulation is a general formulation of the inverse matrix tridiagonal topelitz. Next we will substitute (4) and (5) the common form of all of the above equation into the general equation inverse matrix, namely

$$A^{-1}=\frac{1}{\det(A)}adj(A)$$

or

$$(A_n)^{-1}=\frac{1}{|A_n|}adj(A_n)$$

IV. Conclusion

Before we find inverse of tridiagonal toeplitz matrix by adjoint method, we must determine general formula for determinant and cofactor matrix of tridiagonal toeplitz matrix. After that, we get inverse of tridiagonal toeplitz matrix by substitution determinant and cofactor matrix to equation $(A_n)^{-1}=\frac{1}{|A_n|}adj(A_n)$. The general formula of determinant, cofactor matrix, and inverse of tridiagonal toeplitz matrix are as followed.

1. The general formula of determinant of tridiagonal toeplitz matrix.

$$|A_n|=b^n-(n-1)ab^{n-2}c+\sum_{i=1}^{n-3}ia^2b^{n-4}c^2-\left(\sum_{i=1}^{1}i+\sum_{i=1}^{2}i+\cdots+\sum_{i=1}^{n-5}i\right)a^3b^{n-6}c^3$$
$$+\left[\frac{(n-7)}{1!}\sum_{i=1}^{1}i+\frac{(n-8)}{1!}\sum_{i=1}^{2}i+\frac{(n-9)}{1!}\sum_{i=1}^{3}i+\cdots+1\sum_{i=1}^{n-7}i\right]a^4b^{n-8}c^4$$
$$-\left[\frac{(n-9)(n-8)}{2!}\sum_{i=1}^{1}i+\frac{(n-10)(n-9)}{2!}\sum_{i=1}^{1}i+\cdots+1\sum_{i=1}^{n-9}i\right]a^5b^{n-10}c^5$$
$$+\left[\frac{(n-11)(n-10)(n-9)}{3!}\sum_{i=1}^{1}i+\frac{(n-12)(n-11)(n-10)}{3!}\sum_{i=1}^{1}i+\cdots+1\sum_{i=1}^{n-11}i\right]$$
$$a^6b^{n-12}c^6$$
$$-\left[\frac{(n-13)(n-12)(n-11)(n-10)}{4!}\sum_{i=1}^{1}i+\frac{(n-14)(n-13)(n-12)(n-11)}{4!}\sum_{i=1}^{1}i+\cdots+1\sum_{i=1}^{n-13}i\right]^7b^{n-14}c^7+\ldots$$

2. The general formula of cofactor matrix of tridiagonal toeplitz matrix.

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$$C_n=\begin{bmatrix} (-1)^2|A_{n-1}| & (-1)^3 a|A_{n-2}| & (-1)^4 a|A_{n-3}| & \cdots & (-1)^n a^{n-2}|A_1| & (-1)^{n+1}a^{n-1} \\ (-1)^3 c|A_{n-2}| & (-1)^4 |A_1||A_{n-2}| & (-1)^5 a|A_1||A_{n-3}| & \cdots & (-1)^{n+1} a^{n-3}|A_1||A_1| & (-1)^{n+2} a^{n-2}|A_1| \\ (-1)^4 c^2|A_{n-3}| & (-1)^5 c|A_1||A_{n-3}| & (-1)^6 |A_2||A_{n-3}| & \cdots & (-1)^{n+2} a^{n-4}|A_1||A_2| & (-1)^{n+3} a^{n-3}|A_2| \\ (-1)^5 c^3|A_{n-4}| & (-1)^6 c^2|A_2||A_{n-4}| & (-1)^7 c|A_2||A_{n-4}| & \cdots & (-1)^{n+3} a^{n-5}|A_1||A_3| & (-1)^{n+4} a^{n-4}|A_3| \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ (-1)^n c^{n-2}|A_1| & (-1)^{n+1} c^{n-3}|A_2||A_1| & (-1)^{n+2} c^{n-4}|A_1||A_2| & \cdots & (-1)^{n+n-2}|A_{n-2}||A_1| & (-1)^{n+n-2} a|A_{n-2}| \\ (-1)^{n+1} c^{n-1} & (-1)^{n+2} c^{n-2}|A_1| & (-1)^{n+3} c^{n-3}|A_2| & \cdots & (-1)^{n+n-1} c|A_{n-2}| & (-1)^{2n} c|A_{n-1}| \end{bmatrix}$$

3. The general formula of cofactor matrix of tridiagonal toeplitz matrix is transposed to get the general formula of adjoint matrix of tridiagonal toeplitz matrix.

$$Adj(A_n)=\begin{bmatrix} (-1)^2|A_{n-1}| & (-1)^3 c|A_{n-2}| & (-1)^4 c^2|A_{n-3}| & (-1)^5 c^3|A_{n-4}| & \cdots & (-1)^n c^{n-2}|A_1| & (-1)^{n+1} c^{n-1} \\ (-1)^3 a|A_{n-2}| & (-1)^4 |A_1||A_{n-2}| & (-1)^5 c|A_1||A_{n-3}| & (-1)^6 c^2|A_2||A_{n-4}| & \cdots & (-1)^{n+1} c^{n-3}|A_1||A_1| & (-1)^{n+2} c^{n-2}|A_1| \\ (-1)^4 a|A_{n-3}| & (-1)^5 a|A_1||A_{n-3}| & (-1)^6 |A_2||A_{n-3}| & (-1)^7 c|A_2||A_{n-4}| & \cdots & (-1)^{n+2} c^{n-4}|A_1||A_2| & (-1)^{n+3} c^{n-3}|A_2| \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ (-1)^n a^{n-2}|A_1| & (-1)^{n+1} a^{n-3}|A_1||A_1| & (-1)^{n+2} a^{n-4}|A_1||A_2| & (-1)^{n+3} a^{n-5}|A_1||A_3| & \cdots & (-1)^{n+n-2}|A_{n-2}||A_1| & (-1)^{n+n-1} c|A_{n-2}| \\ (-1)^{n+1} a^{n-1} & (-1)^{n+2} a^{n-2}|A_1| & (-1)^{n+3} a^{n-3}|A_2| & (-1)^{n+4} a^{n-4}|A_3| & \cdots & (-1)^{n+n-2} a|A_{n-2}| & (-1)^{2n} c|A_{n-1}| \end{bmatrix}$$

4. The general formula of inverse of tridiagonal toeplitz matrix.

$$(A_n)^{-1}=\frac{1}{|A_n|}adj(A_n)$$

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Usage of Educational 2D and 3D Animation

Case study: system of biopori

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***Abstract*—Animated films are not only be used as a means of entertainment but also as educational animated. In this research, the researcher study the effectiveness of 2d/3d animation as an instructional media on the subject of biopori system. Biopori subject is classified as non abstract learning materials, it can be observed and demonstrated directly. The method used to measure the level of effectiveness is one group pre-test and post-test quasi-experimental method involving 60 respondents. The first group was given treatment is required to watch 2D animation before doing post-test, while the second group was given a 3D animation as a treatment to test whether a given animation can make respondents better understand the material presented. There is a significant increase in the average value between pre-test and post-test in both types of animation with T test showed that the 3D and 2D animation to get score T-test respectively by 18.91 and 8.91 (higher than t-table 2.045). Further investigation showed that T-test value of two independent groups, experiment group (3d) and controlled group (2d) with difference posttest and pretest as observed data, is 3.92 (higher than t-table 2.66). It is conluded that 3D animation is better than 2D animation as an instructional media for biopori system subject.**

Keywords—educational animation; 2D animation; 3d animation; biopori; instructional media

I. INTRODUCTION

Several studies have been carried out related to educational animation. According to research conducted by [1], animation provides a significant effect in the learning process as compared to verbal communication. Animations can form an image directly on the material to be delivered up to make the audience can better understand a particular topic. Reference [2] developed an animation-based learning system that help students in learning chemistry material subject. Reference [3] developed another model of educational animation to visualize the behavior of the model production activities with engineering manufacturing company Labeled Transition Systems (LTS). Reference [4] investigated the use of animation in the world of education with the results stated that the trend of 3D animation will be critical in supporting the learning-based animation although aspects of the hardware remains an important issue. Although the 3D animation is becoming a trend in the future, but there is no proof yet that late 3D animation is better than the 2d animation in animation based learning. This is according to research by [5] which develops animated learning about the subject of enzyme of ATP-Synthase, an animation that explains the enzymes that act in the human body that causes fatigue. The results suggest that the animation is also a significant influence in the delivery of learning material, but in terms of form or type in the study, 3D and 2D animation does not have a significant difference. The researcher consider enzyme of ATP-Synthase is an abstract concept, meaning that cannot be observed directly, and it is difficult to directly demonstrated or practiced both in the classroom and even in the laboratory. Therefore, it is hypothesized that if the learning material is a material that can be observed directly without using tools (using only the eyes) then animated 3D shape more effective than 2D animation. The researcher developed a study to create 2D and 3D animation education in the case of non-abstract learning materials. The material is how to make the system of biopori. Biopori is the activity of making a water catchment hole using the help of soil organisms such as worms and other organisms, living with a food source, organic waste to form pores of the soil naturally. This increases the volume of groundwater that can be used during the dry season and prevent flooding (water floating) on the soil surface during the rainy season.In addition, Biopori also useful in the utilization of organic waste and the production of compost, it is based on research conducted by [6].

II. THEORY

A. Animation

According to [7], animation is defined as a process of recording and playing back a series of static images to get an illusion of movement. Animation is divided into 2D animation and 3D animation. 2D animation moving objects in two-dimensional space while the 3D animation moving objects in a 3D space. 3-D space is a 2D space given the depth factor.

There are at least 12 principles that must be met to create a "live" animation. The 12 principles include the fundamentals of movement, timing and visual enrichment. Based on the opinion of Ollie Johnston and Frank Thomas [8], in their book Disney Animation: The Illusion of Life: the twelve principles are Solid Drawing, Timing, Squash and Stretch, Anticipation, Slow In and Slow Out, Arcs, Secondary Action, Follow through and Overlapping ActionStraight Ahead Action and Pose to Pose, Staging, Appeal and Exaggeration.

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